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FINAL
INFORMATIONAL FIELD REPORT
WATER WELL ABANDONMENT
Delivery Order 5007

Prepared for
McClellan Air Force Base
Sacramento, California

REGISTERED GEOLOGIST
CHARLES S. ELLIOTT, JR.
No. 4751
STATE OF CALIFORNIA

Charles S. Elliott, Jr.

This document has been prepared under the direction of a registered geologist.

Prepared by

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Sacramento, California 95834

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CONTENTS

TABLES

FIGURES

INTRODUCTION

McClellan Air Force Base (AFB) is located about 7 miles northeast of downtown Sacramento, California (see Figure 1). The base was originally established in 1936 as an air repair depot and supply base for the War Department. During World War II, McClellan AFB became a major industrial facility; in the early 1950s, it became a jet fighter maintenance depot. Today, McClellan AFB is an Air Force Logistics Command Center, occupying about 2,600 acres and employing more than 20,000 people.

Historically, McClellan AFB has used a variety of toxic materials as part of routine operations and maintenance activities. These toxic materials have included industrial solvents, caustic cleaners, electroplating wastes containing heavy metals, jet fuels, and a variety of oils and lubricants (Radian Corporation, 1990). In August 1979 the McClellan AFB Environmental Protection Committee created a special groundwater contamination task force (now inactive) to determine whether groundwater quality problems existed in the area. This voluntary action was prompted by concern that previous use of toxic chemicals, particularly trichloroethylene (TCE), could have affected groundwater quality. Samples collected from several wells on and near the base during 1979 and 1980 confirmed the presence of TCE in certain wells. As a result, those wells were taken out of service.

Investigations have been conducted at McClellan AFB under the Air Force Installation Restoration Program and the Superfund program since the discovery of groundwater contamination. Results of these investigations show that contamination is mainly confined to the uppermost groundwater zones beneath the base. Drinking water wells in the vicinity of the base draw primarily from deeper groundwater zones (Radian Corporation, 1990). Heavy pumping from many of these wells has created a downward gradient of flow in the groundwater system beneath the base.

Concern mounted that existing inactive water supply wells at McClellan AFB may serve as conduits, allowing contaminated groundwater near the water table to migrate to deeper zones through the casing and gravel pack and potentially threaten drinking water supplies downgradient from the base. Therefore, McClellan AFB issued a Statement of Work in June 1990 that authorized a Water Well Abandonment Project to decommission several inactive water supply wells on the base.

Originally, eight inactive water supply wells were targeted for decommissioning. However, four of these wells (Base Wells 3, 6, 16, and 19) were eliminated from consideration because they could not be located. Later, City Well 150 (CW-150), on Astoria Street near the southwestern base boundary, was added to the list for decommissioning. The general locations of the five wells abandoned during the course of this project are shown in Figure 2.

The first project task involved the preparation of a work plan that governed the decommissioning approach. In December 1990, that plan, entitled Well Closure Methods and

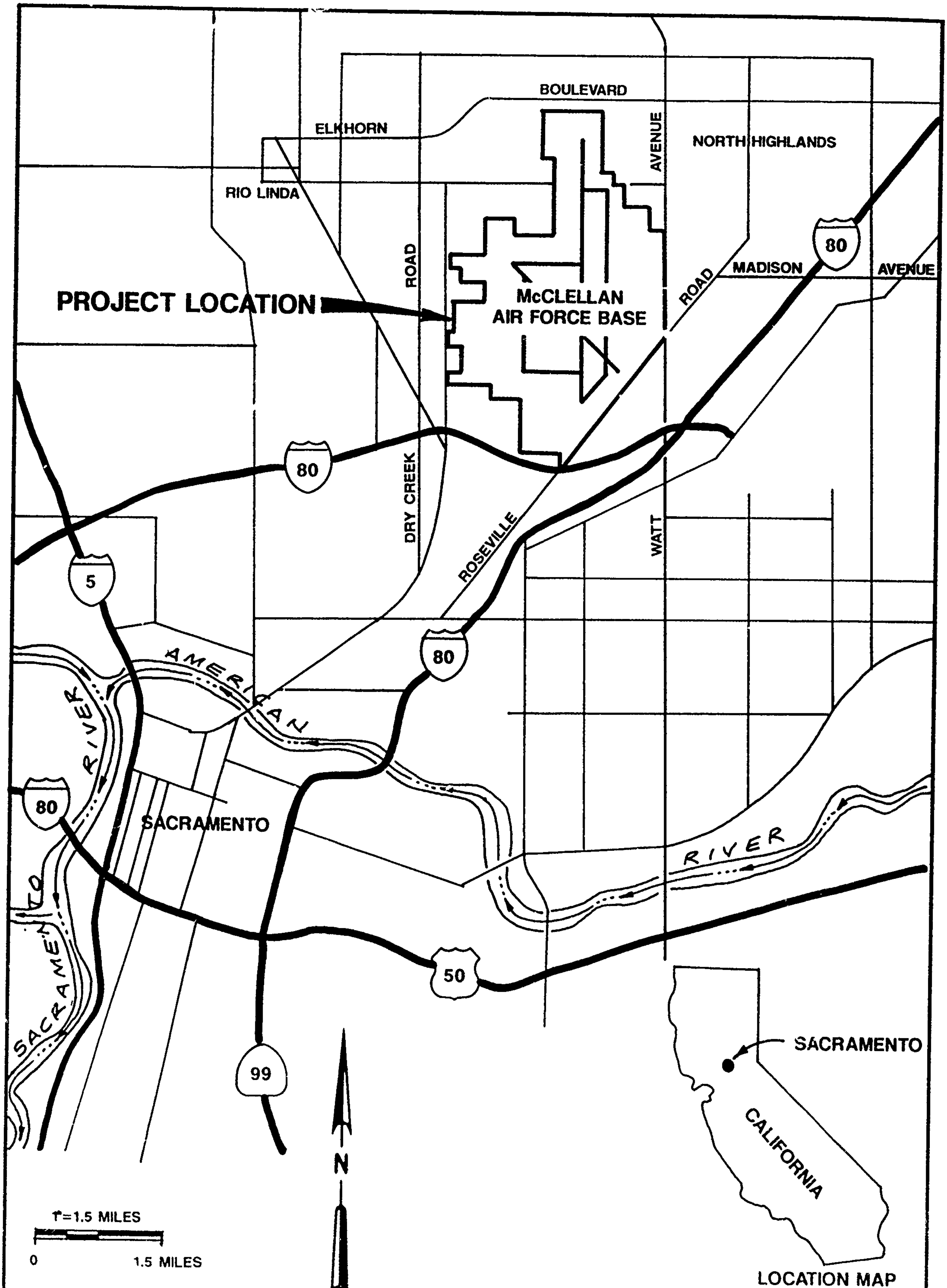

FIGURE 1
LOCATION OF McCLELLAN AIR FORCE BASE

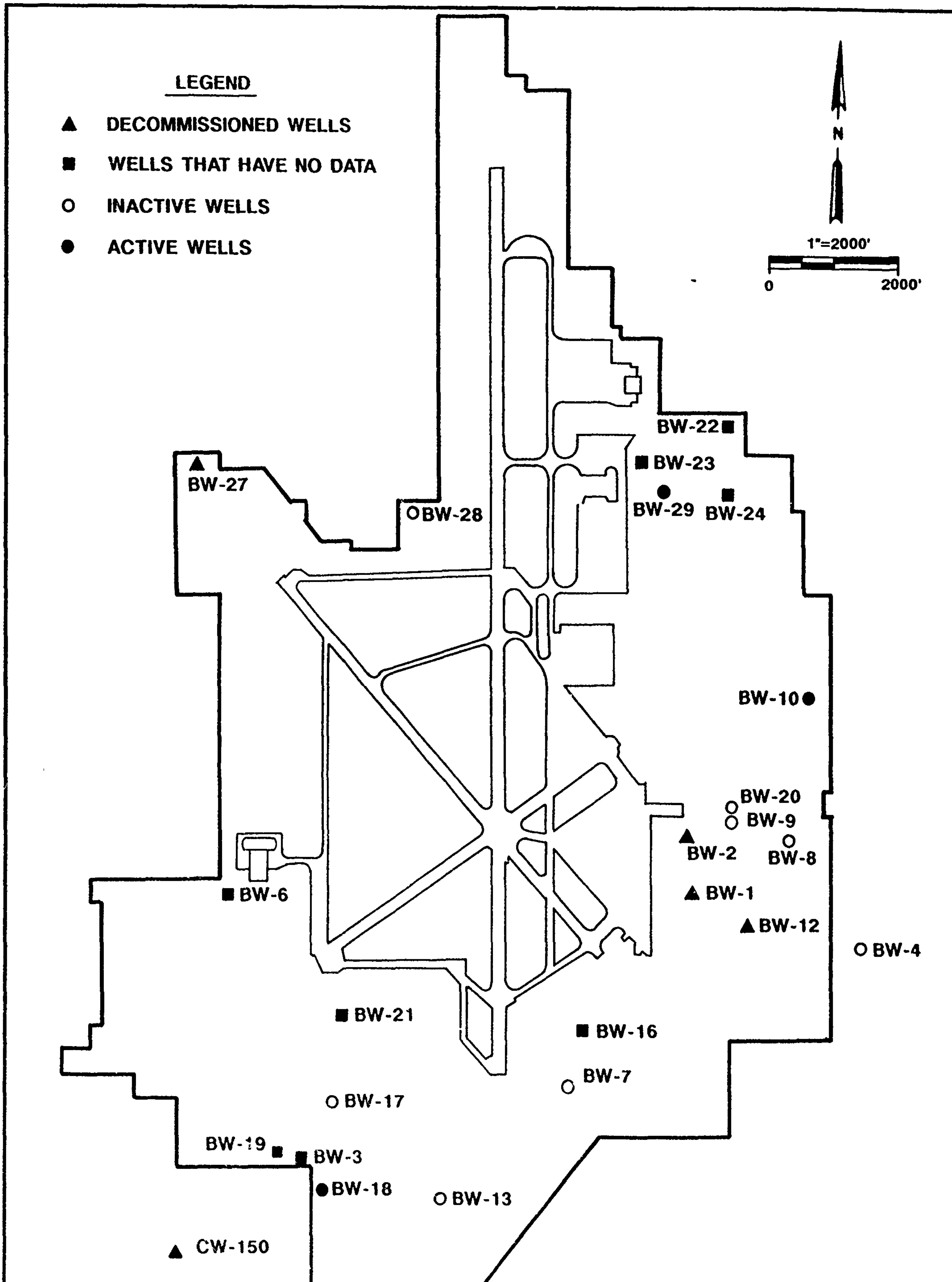

FIGURE 2
PRODUCTION WELLS
AT McCLELLAN AIR FORCE BASE

CH2M HILL

Procedures (the Plan), was submitted to the representatives of agencies party to the Interagency Agreement (IAG), the agencies that govern remedial activities at the base. The Plan was modified to incorporate agency comments and given final approval in January 1991. In addition to proposing a decommissioning approach, the Plan provided a discussion of hydrogeology in the vicinity of McClellan AFB, inventoried existing water supply wells, summarized construction details for wells scheduled for abandonment, proposed a geophysical method to locate wells not visible at the surface, listed applicable regulations governing abandonment, and presented a Health and Safety Plan to govern field work.

Well decommissioning field activities took place between February and July 1991. Field work involved removing existing pumps from three wells, followed by conducting television surveys in each of the wells. Some rehabilitation on the wells was necessary based on the results of the television surveys. After rehabilitation, a second television survey was conducted, followed by cementing operations to plug the wells. Five wells were decommissioned: Base Well No. 1 (BW-1), BW-2, BW-12, BW-27, and CW-150. At the conclusion of each stage of work at each well, equipment was decontaminated by steam-cleaning at a central location on the base.

This document describes the field activities carried out to decommission the five wells including pump removal, television surveying, rehabilitation, and cementing. Based on experience gained in that operation, this report recommends an approach for future well decommissioning activities at the base. It also includes an updated inventory of known base water supply wells and recommends future decommissioning work. Notes maintained during field activities are included as Appendix A.

PRELIMINARY ABANDONMENT ACTIVITIES

PUMP REMOVAL

Pumps were removed from BW-1, BW-2, and BW-12 between February 4 and February 11, 1991, by Layne-Western. Pumps from BW-27 and CW-150 had been removed earlier by McClellan AFB and the City of Sacramento. CH2M HILL supervised the work and monitored safety and ambient air conditions with a photoionization detector, explosimeter, and radiation meter. No elevated readings above background were observed during pump removal or during any other field activities. A technical memorandum was prepared following pump removal and the initial television survey (included in Appendix B). The well locations are shown in Figure 2.

The BW-12 pump was removed first. After the electric motor was removed from the pump shaft and discharge pipes and a drive shaft to an auxiliary generator had been detached, an attempt was made to pull the column pipe and pump bowls from the well. However, the pump could not be lifted from the well with the equipment being used, a rig with 16,000-pound lift capacity. It was necessary to use a larger rig with a

50,000-pound lift capacity, possibly because the pump bowls were wedged against the side of the casing.

The rig with a 16,000-pound lift capacity easily pulled the pumps from BW-1 and BW-2. The only difficulty occurred when the BW-2 pump column pipe would not unscrew at the joints. The pipe was torched and cut. All pumps, motors, and piping were transported to the McClellan AFB Defense Reutilization and Marketing Office (DRMO) at Building 700.

INITIAL TELEVISION SURVEY

On February 12, 1991, downhole television surveys were conducted on CW-150, BW-1, BW-2, BW-12, and BW-27 by Welenco, Inc., under the supervision of CH2M HILL. The purpose of the television surveys was to evaluate the condition of the casing prior to cementing. Attributes noted included depth intervals of existing perforations, depth of the well, presence of obstructions or encrustations in the casing or fill material in the bottom of the casing, and ability of the casing to withstand cementing pressures, as indicated by the presence of cracks or holes, and corrosion along the slots. At each well, a video camera was lowered down the well to the bottom of the casing.

City Well 150

The initial television survey revealed that the casing in CW-150 was in relatively good condition. The casing consisted of 14-inch-diameter steel with horizontal louvered screen beginning at a depth of 143 feet and continuing to the bottom of the well. A thin film of pump lubricating oil was observed floating on top of the water in the well at a depth of 98 feet. At 168 feet, an obstruction that appeared to be a rock, wedged and partially blocking the casing, was encountered. Welenco pulled the video camera out of the well, closed the spring guides that keep the camera centered in the hole, and then lowered it into the well again.

On the second attempt, the camera successfully passed the obstruction without dislodging it. At 183 feet, a small-diameter pipe was observed, apparently an air line associated with the former pump. This air line extended to the bottom of the well, where smaller pieces of air line pipe were also found. A second obstruction was encountered at 334 feet, but gentle prodding with the camera dislodged it.

Beginning at 344 feet, rocks and assorted debris were found in the casing, blocking the camera and halting the survey at 347 feet. It was determined that the lower 25 feet of the well was filled with debris.

Base Wells 1, 2, 12, and 27

The initial television survey revealed that each of the former production wells on McClellan AFB was filled with what appeared to be iron bacteria, making it difficult to

observe the condition of the casing. These bacteria consisted partly of gelatinous material and partly of encrustations of precipitated iron oxide. In each well, the water was cloudy in the blank casing above the top of the slotted interval, but became clearer in the slotted zones, presumably because of the movement of groundwater. However, it was difficult to locate the top and bottom of each interval of slots because the casing was obscured by iron bacteria. In each well, slots consisted of vertical perforations cut in the steel casing. Where visible, the slots were plugged with bacterial deposits.

Both BW-1 and BW-2 contained 12-inch-diameter steel casing, BW-12 contained 14-inch-diameter steel casing, and BW-27 contained 6-inch-diameter steel casing. Because of poor visibility, it was difficult to tell whether construction details in the wells conformed to available data for the wells. In BW-1, the casing appeared to be slightly corroded above the water, with heavier corrosion noted at a depth of 97 feet. Water was contacted in BW-1 at 110 feet, with about 1 foot of lubricating oil floating on the water. The bottom of BW-1 was filled with a soft accumulation of debris at a depth of 355 feet. According to available data, this well was 400 feet deep, indicating that 45 feet of the casing was filled with debris.

Some corrosion was noted in the casing above the water table in BW-2. Visibility below the water table was poor because of the iron bacteria. No lubricating oil was found on the water although the pump had been recently removed. The surface of the water lay in an interval of slots, which probably allowed the oil to migrate out of the well. Soft debris filled the casing at a depth of 288 feet. Because the total depth of BW-2 was 298 feet, it was determined that 10 feet of debris filled the casing.

BW-12 was located in a subsurface vault, about 10 feet below ground surface. A 14-inch-diameter casing was observed, not the 12-inch casing originally reported for this well. Water was contacted at about 109 feet, with about 1 foot of lubricating oil floating on top. As before, visibility in the well was poor. According to available information, BW-12 was slotted continuously from a depth of 164 feet to the total depth of 395 feet. The television survey located the top of the slots at a depth of about 167 feet, but lost track of them at a depth of 350 feet, suggesting that no groundwater movement was occurring through the slots below this depth. A soft bottom was contacted at 384 feet, indicating that the lower 11 feet of casing was filled with debris.

Only a thin film of oil was observed on the top of the water in BW-27, contacted at a depth of 92 feet. The casing below the water was very heavily encrusted with iron bacteria, which obscured the slots throughout most of the well. A soft accumulation of debris filled the casing at a depth of 257 feet. Because the total depth of BW-27 was 262 feet, it was determined that about 4 feet of debris filled the casing.

WELL REHABILITATION

The initial television survey revealed the need for rehabilitation work on the five wells. McClellan AFB authorized this work, which was performed by Layne-Western under the supervision of CH2M HILL from March 13, to March 27, 1991. Rehabilitation of

CW-150 involved retrieving sections of air line pipe from the well with a bailer. A total of 322 feet of piping was removed from CW-150 and transported to DRMO for disposal. Other obstructions and debris, including sticks and stones, were also removed from the well. At the conclusion of work at this well, 2 feet of soft sediment remained.

The first action taken at base wells was to bail the 1 foot of lubricating oil floating on the water in BW-1 and BW-12. This oil was placed in 55-gallon drums, which were sealed and stored at the wellhead. Because oil mixed with water during the bailing, two drums were used at each well to ensure that all oil was removed. The oil was disposed by a petroleum recycler at the conclusion of the project.

Each of the base wells was cleaned to remove iron bacteria and encrustations from the casings. Several removal methods were evaluated prior to cleaning. Chemical methods, such as adding hypochlorite or acid solutions with swabbing and pumping, were rejected because of the need to avoid pumping and disposing of potentially contaminated water. Sonar jetting to remove the encrustations was also rejected because the condition of the casing was unknown, and this method could damage or collapse the casing.

The technique for base well cleaning used involved raising and lowering a steel brush along the inside of the casing to dislodge iron bacteria and encrustations. Each well was slowly brushed from top to bottom in 200-foot strokes until the casing was judged to be clean. The brush was fabricated by drilling closely spaced holes in a 6-foot length of steel pipe. Steel cable was then drawn through the pipe and cut at a length that corresponded to the diameter of the casing. The cable was unraveled so that steel wire formed a rigid brush. Brushes of 6-, 12-, and 14-inch-diameters were prepared for the four base wells to accommodate their different casing diameters.

SECOND TELEVISION SURVEY

Layne-Western conducted a second television survey in the base wells on March 28, 1991. A second survey of CW-150 was not necessary because the initial survey had shown the casing and well screen to be in good condition. The second television survey revealed that bacteria and encrustations had been successfully removed from each of the base wells. Well casing appeared to be solid and in reasonably good condition in BW-1, BW-2, and BW-27. However, the casing in BW-12 was in an advanced state of deterioration, with cracks and holes at numerous locations. Many of the slotted perforations appeared to have "ragged" edges, suggesting that corrosion had occurred. The second survey also revealed that the 14-inch-diameter casing extended only to a depth of 140 feet. Below that depth, casing was 12 inches in diameter.

CEMENTING OPERATIONS

Wells were abandoned by cementing between March 29 and July 26, 1991, according to procedures outlined in the Plan. Cement materials and equipment were provided by Halliburton Services, with support rigs, piping and perforating equipment supplied by Layne-Western. CH2M HILL supervised the abandonment activities.

GROUT MATERIALS

Several types of cements and additives were listed in the Plan for use in decommissioning wells at McClellan AFB. These included API Class G and H cements, chemically similar to common portland cement but manufactured to rigorous chemical and physical specifications, resulting in a more uniform, fine-grained product (Halliburton Services, 1981). Class H cement is commonly mixed by Halliburton Services in a 50/50 ratio with pozzolans, siliceous materials that develop cementing properties by reacting chemically in the presence of lime and water. When mixed with cement in dry bulk form, pozzolans decrease the weight of the slurry, provide low permeability and low water/solids ratio, and make pumping easier. The 50/50 mixture, marketed by Halliburton as Pozmix, has a hydraulic conductivity of less than 10^{-10} cm/sec after curing (Halliburton Services, 1981). Pozmix was the basic cement used in decommissioning wells at McClellan AFB.

A special cement known as standard fine cement was used during cementing at BW-1 and BW-12. Marketed by Halliburton Services as Matrix Cement, this cement was not listed in the Plan but was approved by the California Department of Health Services (DHS) during the abandonment process because of its useful properties. A Material Safety Data Sheet (MSDS) for Matrix Cement is included in Appendix C. Matrix Cement is chemically similar to portland cement. However, Matrix Cement particle sizes are approximately 10 times smaller than standard cement particles. This property reduces the viscosity of the cement and enables it to penetrate openings as fine as 0.05 mm (Halliburton Services, 1991).

Various additives were mixed with the cement to improve the characteristics of the grout material. During the decommissioning, additives included bentonite powder, CFR-3, calcium chloride, Flocele, and quick-setting gypsum cement. Bentonite powder was dry-mixed with Pozmix at a ratio of 2 percent. Bentonite increases the slurry and set volume and reduces shrinkage because of the water adsorption properties of colloidal clay. Bentonite also improves the suspension quality of the mix, thus reducing the settling out or separation of cement particles from the slurry (Halliburton Services, 1981).

CFR-3 is a dispersant, or friction reducer, composed of sulfonic acid salt. This additive improves the mixing of other components of the grout by increasing the turbulent flow of the slurry, a property that also aids in penetrating gravel packs. In addition, CFR-3 increases cement density, aids in fluid-loss control, and increases the salt tolerance of

the grout if calcium chloride is added (Halliburton Services, 1985). At McClellan AFB, CFR-3 was typically added to Matrix Cement to create a mix with maximum ability to move through slotted casing and penetrate the gravel pack.

Calcium chloride, available in powdered or flake form, was added to the mix in quantities of about 2 to 3 percent to accelerate the early strength of the cement, thus reducing the time required for the mix to set up. Calcium chloride was added either to the dry mix or to the mixing water. For example, Class H cement with 2 percent calcium chloride achieves a compressive strength of 1,100 psi after 6 hours at 95°F (Halliburton Services, 1981). Experience showed that the cement set up more quickly when the calcium chloride was added to the dry mix at the plant.

Two additives were used to reduce losses to permeable formations. Flocele consists of cellulose film flakes, about 3/8-inch in diameter, that are chemically inert and do not affect the compressive strength of the cement (Halliburton Services, 1985). Flocele was added to the mixing water at a ratio of about 0.75 percent by weight. Cal-Seal, or gypsum (calcium sulfate), sets up in 20 minutes when blended with portland cement. In addition, it expands 0.3 percent in setting, forming a tight seal. These properties make Cal-Seal a good choice to seal lost circulation zones (Halliburton Services, 1985). Cal-Seal was mixed with Class G cement at a ratio of about 8 percent to help seal off permeable zones in BW-1. Cellulose flakes and gypsum were listed in the Plan, but MSDS sheets were not included. Therefore, MSDS sheets for Flocele and Cal-Seal are included in Appendix C.

GROUT PLACEMENT

The Plan proposed that wells be decommissioned using a downhole squeeze method. Squeeze grouting can be defined as applying external pressure to the cement to force it through the casing perforations into the gravel pack until it forms a seal against the formation wall. A downhole squeeze involves applying the external pressure downhole, rather than at the wellhead. Using this approach, the well is cemented in a series of lifts. Pressure is applied on each lift to obtain improved control and minimize cement losses to permeable zones. The goal is to ensure that low-permeability zones, or aquitards, are sealed to prevent cross-migration of groundwater among aquifer zones along the borehole.

During the cementing operations, the process outlined in the Plan was modified in response to field conditions. However, the Plan's basic approach (abandonment in lifts using a downhole squeeze) was retained. The following sections describe the procedures followed at each well. This report also contains a modified abandonment approach that is recommended for use in future abandonment efforts at McClellan AFB.

City Well 150

CW-150, the first well to be decommissioned, was abandoned between April 1 and April 8, 1991. Table 1 provides a summary of CW-150 cementing operations. This well was operated by the City of Sacramento. It is located near the southwest base boundary, as shown in Figures 2 and 3. A representation of cementing operations in CW-150 is shown in Figure 4.

CW-150, constructed in 1967, was 372 feet deep. The casing was 14 inches in diameter and was contained within a 28-inch borehole. The gravel pack consisted of one part pea gravel and one part sand. Because the pore spaces of the gravel pack were filled with sand, the assumption of a 40 percent porosity may have been high. The volume of cement required to fill the empty casing plus the gravel pack is 2.35 cubic feet of cement per foot of rise assuming a 40 percent porosity; 2.03 cubic feet of cement per foot of rise assuming a 30 percent porosity; and 1.71 cubic feet of cement per foot of rise assuming a 20 percent porosity. CW-150 was screened continuously from 144 feet to the total depth of the well with 1/8-inch louvers. Thus, it was only necessary to perforate this well from 85 feet to 140 feet. Groundwater lay at a depth of about 98.5 feet.

On April 1 it was discovered that the cup packer would not fit in the casing, delaying cementing until April 4 while Halliburton fabricated a new packer. During this downtime, it was decided to have the Layne-Western crew perforate the blank sections of casing on BW-1 in order to get a head start on that well and avoid paying standby time.

The diameter of the cup packer was considered critical to achieving an effective squeeze. The cup packer diameter needed to be about one-eighth inch smaller than the inside diameter of the casing. Smaller diameters would not ensure that the casing seal would withstand high pressures, and larger diameters would not move easily down the casing. Although other types of retrievable packers are available in the oil industry, all are designed for API casing, and do not fit water well casing. At this stage of the project, it was not known that a cup packer would not work in continuously-screened wells such as CW-150.

The first lift was pumped on April 4, with the tremmie pipe set at 360 feet. Tremmie pipe consisted of 20 foot sections of 2½-inch-inside-diameter threaded steel pipe. The first step was to pump about three barrels, or 126 gallons, of water down the pipe to establish circulation and make sure there were no obstructions. Next, as shown in Table 1, about 36 cubic feet of Pozmix with bentonite and calcium chloride, adjusted to a density of 14.1 pounds per gallon, was pumped into the well. A sample of the grout was collected from the tank and placed in the shade. Following cement placement, three joints of tremmie pipe were removed from the well to avoid cementing it in the well. Then about 15 gallons of water were flushed through the system to clean cement residues from the mixer, pump, and lines. This dilute wash water was pumped down the well to avoid additional disposal problems. Afterwards, the remaining pipe was pulled from the well and fitted with the cup packer.

Table 1
Summary of Cementing Operations at City Well No. 150

Perforated Interval (ft)	Depth Packer Set (ft)	Interval Cemented (ft)	Rise (ft)	Grout Formulation	Density (lb/gal)	Cement Volume (ft^3)	Cement Vol. Per Foot of Rise (ft^3/ft)
372-144 (existing)	N/A[a]	372-359	13	Pozmix 2% bentonite 3% $CaCl_2$	14.1	36.2	2.78
Same	N/A	359-330	29	Pozmix 2% bentonite 3% $Cacl_2$	14.1	60.5	2.09
Same	N/A	330-215	115	Pozmix 2% bentonite 3% $Cacl_2$	14.1	231.0	2.01
Same	N/A	215-141	74	Glass G Cement 2% bentonite 3% $Cacl_2$ 0.75% CRF-3	15.6	125.6	1.70
140-85 (new)	N/A	141-109	32	Class G Cement 2% bentonite 0.75% CRF-3	15.6	49.1	1.53
Same	50	109-77	32	Class G Cement 2% bentonite 3% $Cacl_2$ 0.75% CRF-3	15.6	62.8	2.26[b]
N/A	N/A	77-5	72	Pozmix 2% bentonite 3% $Cacl_2$	14.1	77.0	1.07[c]

[a]N/A = Not Applicable
[b]Assumed cement filled only the casing above 85 feet
[c]Casing Volume = 1.07 ft^3/ft

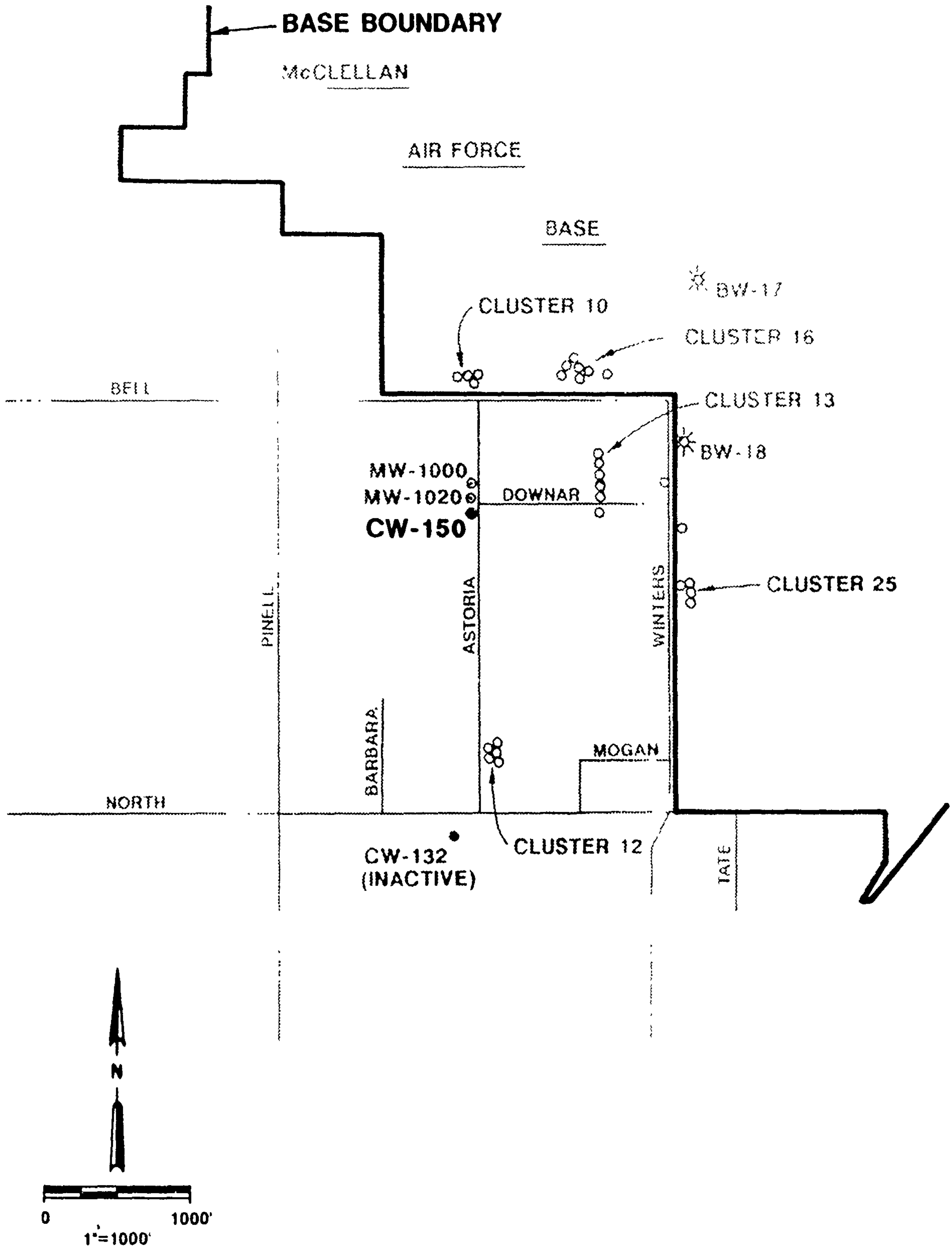

FIGURE 3
LOCATION OF CITY WELL NO. 150
McCLELLAN AIR FORCE BASE

SOURCE: RADIAN, 1989

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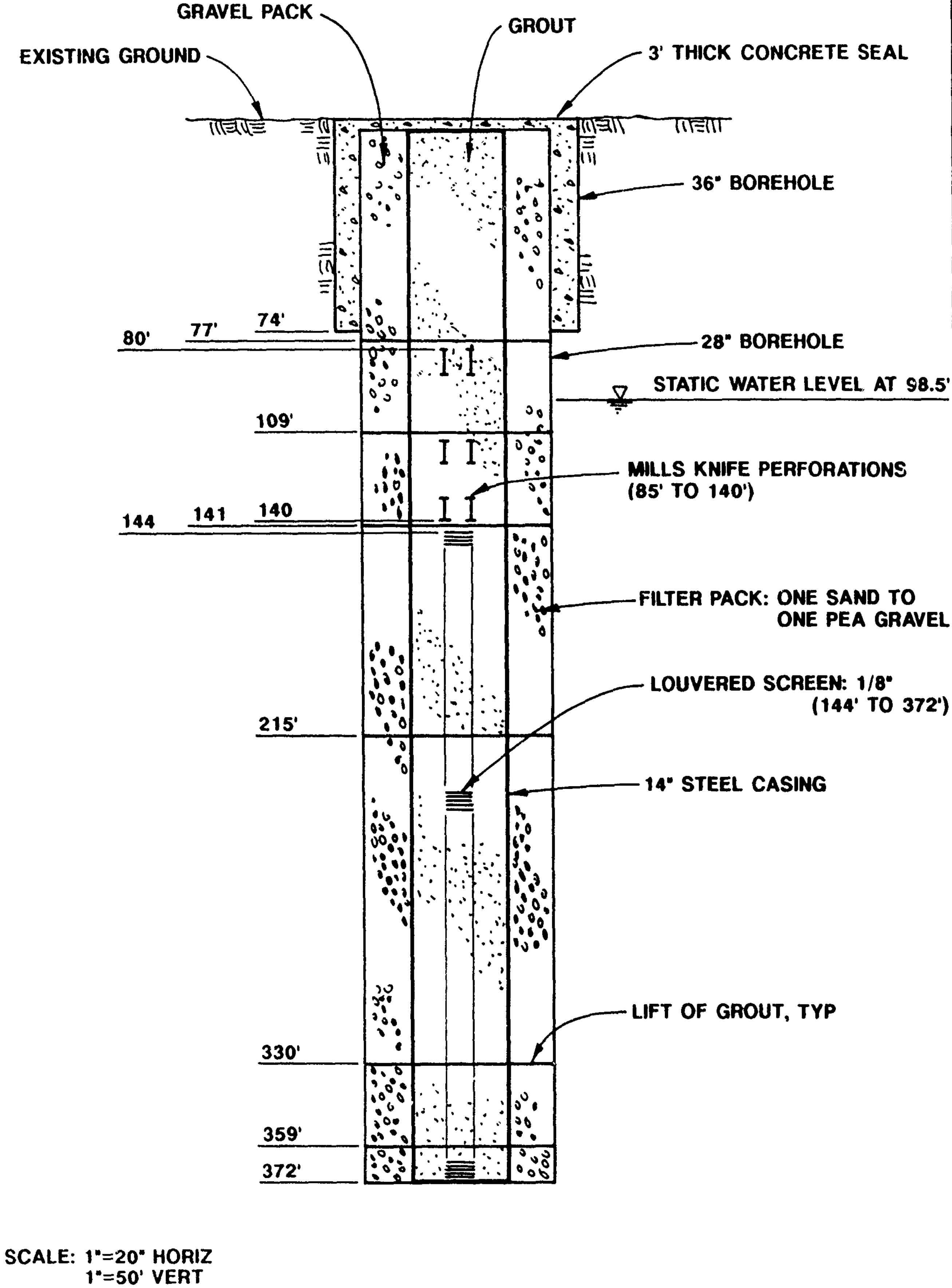

FIGURE 4
CEMENTING OPERATIONS AT CITY WELL NO. 150
McCLELLAN AIR FORCE BASE

CH2M HILL

It proved difficult to force the packer down the well, even with the smaller diameter. By using a winch and applying a head of water above the packer, the crew was able to move it down to about 88 feet. By this time, nearly 2 hours had elapsed since the cement was pumped. After conferring with Halliburton, it was decided to pull the packer from the well and immediately apply a head of water. Continuing to push the packer down the hole would have been time consuming and would risk damaging the casing. Squeezing on cement that was setting up at a depth of 370 feet with a packer at 88 feet was not attempted because the pressure would have been dissipated in permeable zones along the way. Applying a downhole squeeze with a cup packer in CW-150, a well that was continuously screened, was also not an acceptable procedure. It would be difficult to maintain pressure on the cement because pressure would be lost through the perforations above the cement and below the packer. Even if the adjacent formation were a tight clay, pressure would be lost as water moved vertically in the surrounding gravel pack.

Halliburton research has shown that Pozmix will migrate through a well screen and gravel pack under a driving pressure of less than 30 psi (Halliburton, 1987). A copy of this research is included in Appendix D. The hydrostatic pressure exerted by a column of water is about 0.433 psi per foot. Thus, a driving pressure of 30 psi is obtained by a column of water about 70 feet high. This pressure is transmitted evenly to all points in the well below the head of water. After removal of the packer from CW-150, water was pumped into the well at a sufficient rate to fill the casing to the ground surface. A head of 98.5 feet of water applied a differential pressure of about 43 psi to the cement. This head of water was maintained during cement set-up time.

Tremmie pipe was run into the well to tag the top of the cement in the casing after the previously collected cement sample had set up. The cement was considered set up when it would support the weight of the entire string of tremmie pipe. This test procedure was considered adequate because grout develops greater compressive strength in the gravel pack than in the open casing, due to greater bonding area available to the cement in the pore spaces of the gravel pack.

In this manner, CW-150 continued to be cemented in a series of lifts as shown in Table 1. Because the well contained louvered screen from 144-372 feet, it was unnecessary to perforate the casing during this interval. However, the casing was perforated from a depth of 85-140 feet, as shown in Table 1. Perforations were cut with a hydraulic mills knife. At a depth of 215 feet, it was decided to vary the grout formulation in an effort to improve the ability of the grout to penetrate the gravel pack. Concern had centered on the possibility that known permeable zones in the vicinity of CW-150 would cause excessive losses to the formation. However, the well was taking slightly less cement than ideal at an assumed of 40 percent porosity in the gravel pack. Class G cement was tried with CFR-3 added, and the density increased to more than normal (from about 14.8 to 15.6 pounds per gallon). However, this mix proved less successful than the Pozmix and was not used in abandonment at the other wells.

The cup packer was used on the next-to-last lift, where it was set at a depth of 50 feet. Water was pumped through the tremmie pipe until the packer and piping began to lift from the ground while chained and held down with the mast on the pump rig. Water pressure was eased and reapplied in a continuous cycle as the cement set up. The final lift was gravity fed through tremmie pipe until the cement remained at a depth of about 5 feet. Later, the casing was cut at a depth of about 3 feet, and a 3-foot-diameter hole was dug around the well. This space was filled to the ground surface with concrete.

Base Well 27

BW-27 was decommissioned between April 9 and April 12, 1991. The location of BW-27 is shown in Figures 2 and 5. Table 2 and Figure 6 summarize the history of cementing operations at BW-27.

BW-27 was constructed in 1962, with 6-inch-diameter casing. The borehole diameter was not listed on the Well Drillers Report, but the conductor casing was listed as 12 inches in diameter. Thus, the borehole diameter was estimated to be 12 inches. The composition of the gravel pack was also unknown, but the volume of cement required to decommission the well was about 0.43 cubic foot of cement per foot of rise assuming a 40 percent porosity, about 0.38 cubic foot of cement per foot of rise assuming a 30 percent porosity, or 0.32 cubic foot of cement per foot of rise assuming a 20 percent porosity.

The downhole squeeze approach to well abandonment was refined at BW-27. As at CW-150, tremmie pipe was lowered in the well for the first lift to a position about 10 feet above the bottom, or a depth of about 250 feet. The minimum amount of cement that Halliburton could mix and pump at one time was about three barrels, or 16.8 cubic feet. The grout formulation used throughout the abandonment of BW-27 was Pozmix, with 2 percent bentonite gel and 3 percent calcium chloride. First, about three barrels of water was pumped through the tremmie pipe to establish circulation, after which 16.8 cubic feet of Pozmix was pumped down the well. The pipe was pulled up about 60 feet and approximately 15 barrels of water pumped through the mixer, pump, and pipe to flush and clean the system of cement. Next, the tremmie pipe was withdrawn from the well and fitted with a cup packer. The cup packer was lowered in the hole but became very difficult to push at a depth of about 175 feet. Because the cup packer might have been pushing cement, it was decided to set the cup packer at a depth of 200 feet and pump water to apply pressure. About 60 psi was achieved and 2.5 barrels of water had been pumped when all pressure was lost. After the pump was turned off, water continued to drain from the mixing tank under the force of the head of water in the pipe. This indicated that a permeable zone was taking all the water that could be applied. To avoid cementing the cup packer in the hole, it was removed from the well. Water was pumped into the well at about 400 gpm to apply a head. Setup was judged in the same manner as CW-150. When the sample was set, the tremmie pipe was run down the hole to tag the top of the cement. The top was found at a depth of 251 feet, indicating a large amount of cement was lost to a permeable zone:

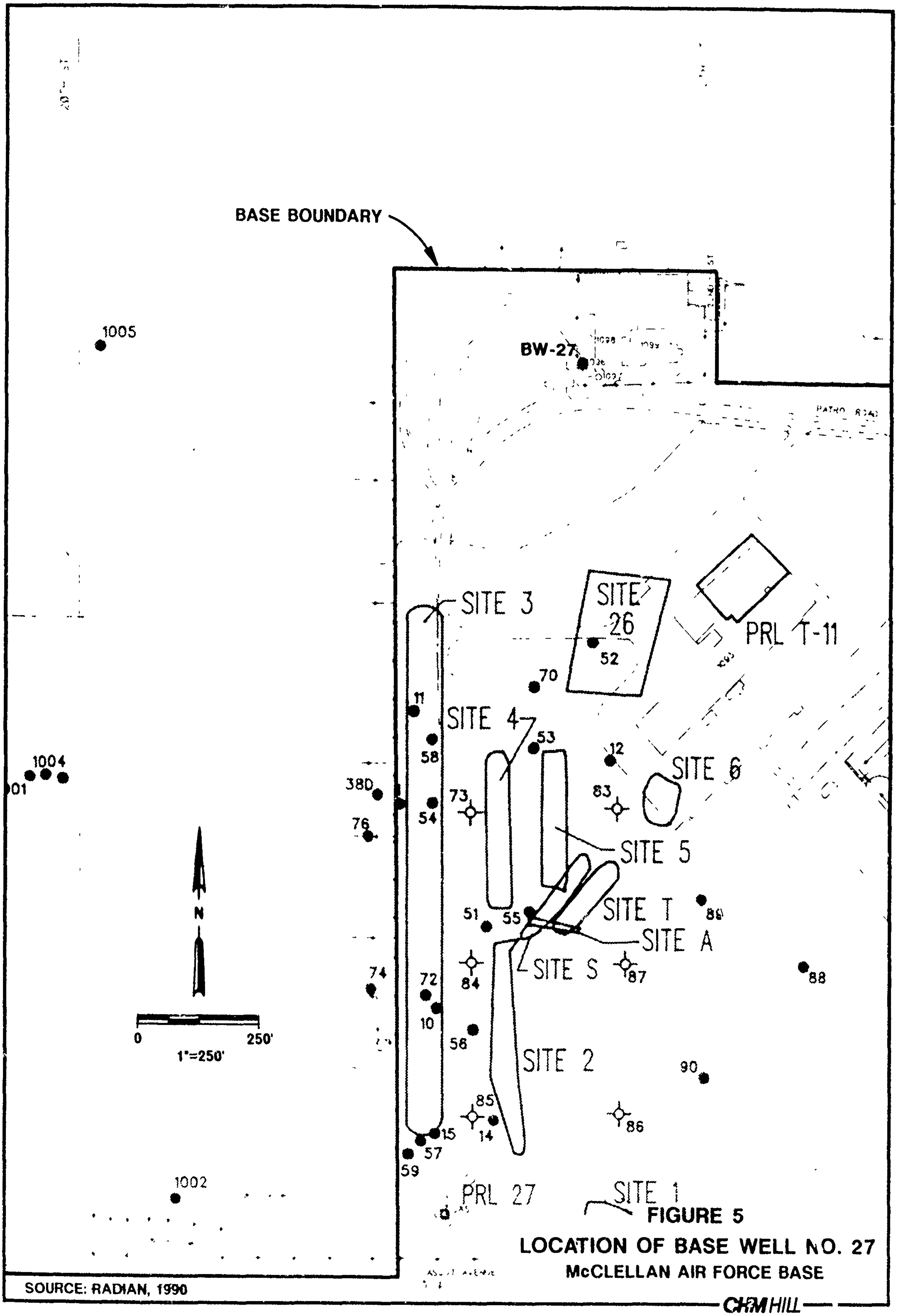

FIGURE 5
LOCATION OF BASE WELL NO. 27
McCLELLAN AIR FORCE BASE

CH2M HILL

Table 2 Summary of Cementing Operations at Base Well No. 27							
Perforated Interval (ft)	**Depth Packer Set (ft)**	**Interval Cemented (ft)**	**Rise (ft)**	**Grout Formulation**	**Density (lb/gal)**	**Cement Volume (ft^3)**	**Cement Vol. Per Foot of Rise (ft^3/ft)**
260-240 (existing)	200	260-251	9	Pozmix 2% bentonite	14.3	16.8	1.87
Same	200	251-225	26	Pozmix 2% bentonite 3% $Cacl_2$	14.1	16.8	0.67
210-200 (existing)	130	225-186	39	Pozmix 2% bentonite 3% $Cacl_2$	14.1	19.7	0.51
185-175 (existing)	125	186-171	15	Pozmix 2% bentonite 3% $Cacl_2$	14.1	22.5	1.50
174-153 (new)	125	171-146	25	Pozmix 2% bentonite 3% $Cacl_2$ 0.25% flocele	14.7	22.5	0.90
139-109 (new)	79	146-108	38	Pozmix 2% bentonite 3% $Cacl_2$	14.1	22.5	0.59
101-80 (new)	2	108-80 80-9	28 71	Pozmix 2% bentonite 3% $Cacl_2$	14.1	22.5	0.30 0.20[a]

[a]Casing volume = 0.20 ft^3/ft

SAC/1183 002 51

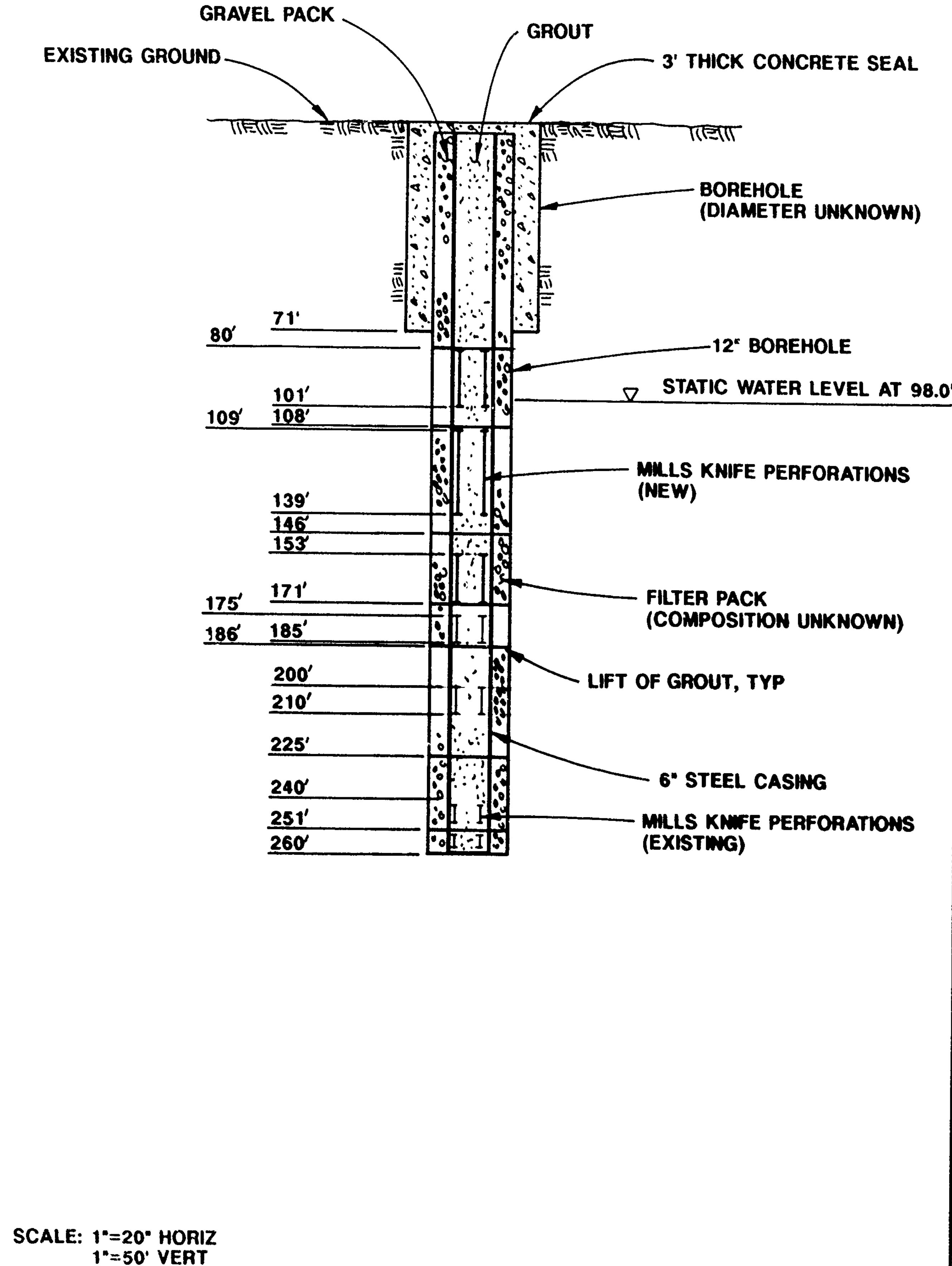

FIGURE 6
CEMENTING OPERATIONS AT BASE WELL NO. 27
McCLELLAN AIR FORCE BASE

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For this lift, 1.87 cubic feet of cement had been used per foot of rise, while 0.43 cubic feet would be expected, assuming a 40 percent porosity in the gravel pack.

After conferring with Halliburton, it was decided to install the cup packer as a first step rather than pump cement through the tremmie pipe, remove the pipe, then run back in with the packer. Cement was pumped through the cup packer, followed by water to apply a squeeze. This saved time, because the previous process had required about 1 hour to complete. During that hour, the cement would begin to set up, resulting in a loss of control.

The cup packer was set at a depth of 223 feet. Two barrels of water were pumped to establish circulation, and another 16.8 cubic feet of Pozmix was pumped into the well. As water was pumped behind the cement, the packer and tremmie pipe began to rise out of the well, even at the lowest pumping rate (about one-half barrel per minute); the gauges indicated that the pump was pushing against about 60 psi. Because of concern that the lower perforations (at 240 to 260 feet) were sealed off, the cup packer was raised above the next set of perforations (at 200-210 feet) and set at a depth of 200 feet. Sufficient water was pumped to displace the cement from the lines and push it into the casing. The cup packer was pulled up to avoid cementing it in the hole. As with CW-150, wash water was flushed down the well, the cup packer and tremmie were removed, and a head of water was applied during set up.

Because of problems encountered at BW-27, the approach was modified further. The new approach involved setting the cup packer in a section of blank casing above a zone of existing perforations, or a zone that had been perforated in preparation for cementing. A volume of cement, calculated to fill the section of perforated casing and 40 percent of the gravel pack and extend about 2 feet in the casing above the perforated zone, was prepared. The volume of water required to fill the blank casing above the expected top of cement and below the cup packer and the volume of tremmie pipe and the above-ground piping downstream from the pump, where the flow was gauged, was calculated. The cement was pumped, pushed by the water pumped behind, and forced into the gravel pack. The pressure needed to push the cement was obtained by the hydraulics of pumping water through a small-diameter pipe into the large-diameter closed piston formed by the casing below the cup packer. After the calculated volume of water was pumped, the top of the cement would lie at approximately the calculated depth, having been displaced by the water. The cup packer was then removed from the well to avoid the possibility that cement would migrate up the gravel pack, enter the casing through perforations above the packer, and cement the cup packer in the hole. Following removal of the packer, one section of tremmie pipe was hung in the well and cement wash water pumped down the hole.

This modified approach was followed at BW-27 with great success. If necessary, blank casing was perforated prior to cementing. Table 2 summarizes the history of cementing and perforating. Perforations were cut with a hydraulic mills knife. Remaining problems included difficulty tagging the top of cement with the tremmie pipe; occasionally the pipe would hang up in the casing above the cement, giving the

impression that the cement was higher than it actually was. Confirmation tagging with a weighted line solved this problem. One zone in BW-27 took too much cement, but this was resolved by the addition of Flocele in the subsequent batch.

On the next-to-last lift, cement was brought to within 15 feet of the water table, and the casing was perforated about 12 feet above the water table. On the final lift, the cup packer was set at a depth of 2 feet and cement was pumped to fill the casing to within 9 feet of the surface, forcing all water out of the well through the perforations and avoiding the need to dispose of any well water. Cement wash water was transported to the wastewater treatment plant for disposal. Later, the casing was cut at a depth of 3 feet below the ground surface, and a 3-foot-diameter hole was dug around the casing. This space was filled to the ground surface with concrete.

In summary, a successful abandonment approach was developed at BW-27 that safely employed the downhole squeeze and provided maximum control. With this approach, it is possible to mix the exact amount of cement needed to seal a given interval and be reasonably confident that, after setting up, the top of the cement will lie about where it is expected. Although the approach would not work at wells that were continuously slotted, such as CW-150, or at wells where the casing was too weak to sustain the tremendous hydraulic pressures generated by pumping water into the closed piston below the packer, the downhole squeeze appears to be a promising technique for future well abandonment efforts at McClellan AFB.

Base Well 2

BW-2 was decommissioned between April 12 and April 17, 1991. The location of the well is shown in Figures 2 and 7. Table 3 and Figure 8 summarize the cementing and perforating operations for BW-2. BW-2 was located inside Building 232, with access through a trapdoor in the roof. Constructed in 1937, BW-2 was 296 feet deep, with a casing diameter of 12 inches and a borehole diameter of 18 inches. The filter pack consisted of pea gravel. The volume of cement calculated to abandon BW-2 was 1.18 cubic feet of cement per foot of rise assuming a 40 percent porosity in the gravel pack, and 1.08 cubic feet of cement per foot of rise assuming a 30 percent porosity. The static water level in this well was 109.3 feet below the wellhead.

The cementing approach developed at BW-27 was employed with success at BW-2, with the exception of the first lift. Existing perforations lay at depths of 281 to 296 feet, 180 to 197 feet, 141 to 158 feet, and 100 to 110 feet. On the first lift, the cup packer was set at a depth of 260 feet. As a first step, about five barrels of water were pumped down the hole to establish circulation. By circulating water in the hole with the cup packer set, the operator was able to determine whether the perforations were open and ready to be cemented. Also, by monitoring the pressure gauge, it was possible to estimate the relative permeability of the adjacent formation. For example, if positive pressure was required to pump the water, then the formation might be relatively low in permeability and consist of silt or clay. On the first lift in BW-2, no pressure was developed when water was circulated. In fact, after the pump was turned off,

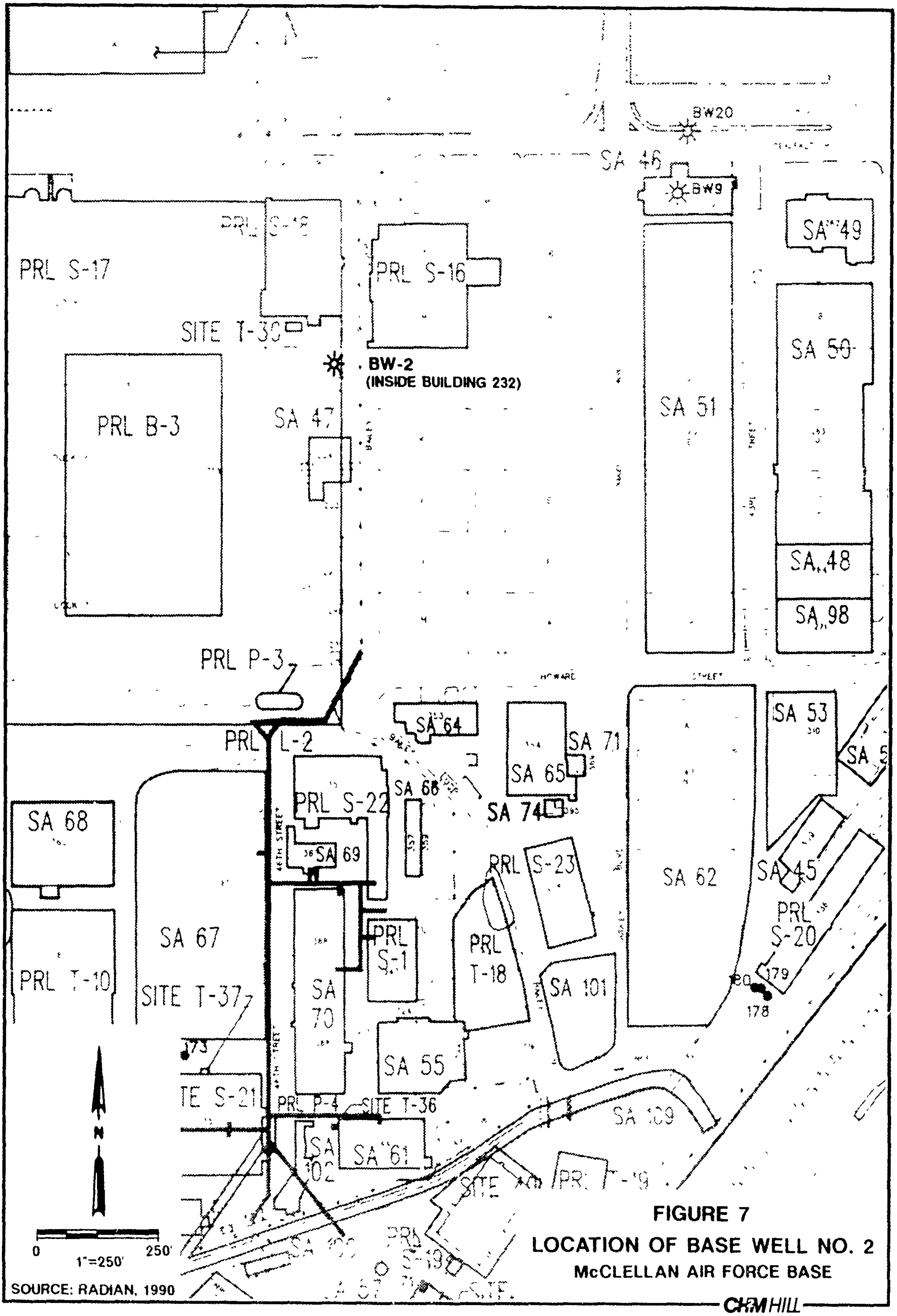

FIGURE 7
LOCATION OF BASE WELL NO. 2
McCLELLAN AIR FORCE BASE

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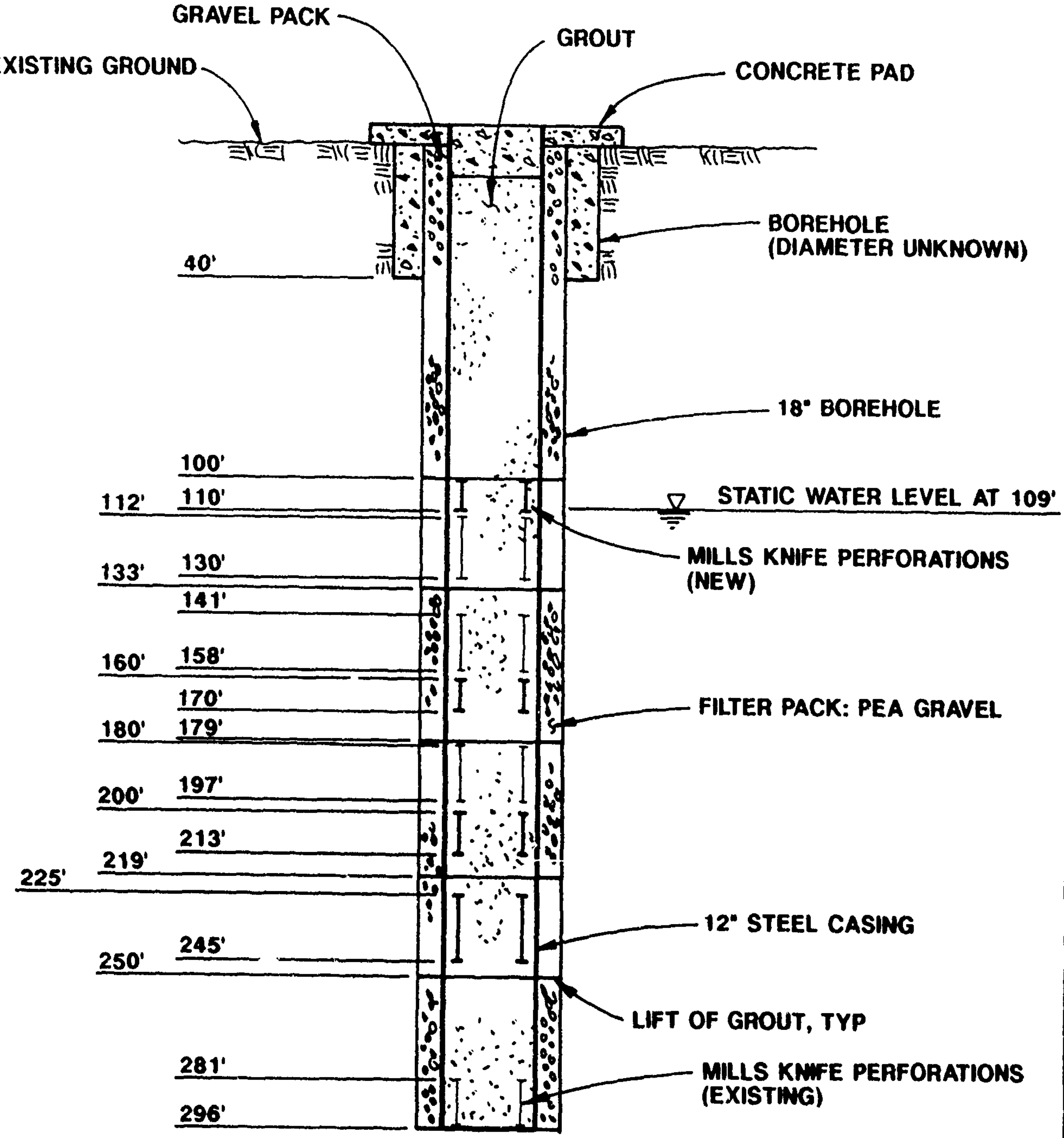
Table 3 Summary of Cementing Operations at Base Well No. 2							
Perforated Interval (ft)	Depth Packer Set (ft)	Interval Cemented (ft)	Rise (ft)	Grout Formulation	Density (lb/gal)	Cement Volume (ft^3)	Cement Vol. Per Foot of Rise (ft^3/ft)
296-281 (existing)	260	?[a]	?[a]	Pozmix 2% bentonite 3% $Cacl_2$ Flocele	14.55	28.3	?[a]
245-225 (new)	205	250-219	31	Pozmix 2% Gel Flocele	14.5	44.5	1.44
213-200 (new) 197-180 (existing)	170	219-179	40	Pozmix 2% bentonite 3% $Cacl_2$ Flocele	14.1	64.7	1.62
170-160 (new) 158-141 (existing)	130	179-133	46	Pozmix 2% bentonite 3% $Cacl_2$ Flocele	14.1	64.7	1.41
130-112 (new) 110-100 (existing)	90	133-100	33	Pozmix 2% bentonite 3% $Cacl_2$	14.1	56.6	1.72
N/A[b]	N/A[b]	100-9	91	Pozmix 2% bentonite 3% $Cacl_2$	14.1	71.9	0.79[c]

[a]Unable to tag
[b]N/A = Not Applicable
[c]Casing Volume = 0.79 ft^3/ft

SAC/T183/003 51



SCALE: 1"=20" HORIZ
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FIGURE 8
CEMENTING OPERATIONS AT BASE WELL NO. 2
McCLELLAN AIR FORCE BASE

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water continued to drain from the tank into the well under the driving force of the head of water in the pipe. This indicated that the perforations were open and the formation was relatively permeable and might consist of sand or gravel. Therefore, it was decided to add Flocele to the Pozmix, bentonite, and calcium chloride grout mix.

As before, a volume of grout was calculated to fill the casing and the gravel pack. A volume of water was calculated to push the grout down below the cup packer and leave the top of cement about 4 feet above the top of the perforations. After the grout and water had been pumped, the cup packer was pulled from the well and cement wash water was pumped down the hole. Then the grout was allowed to set up.

However, when the top of cement was tagged, both the tremmie pipe and weighted line were unable to move past a depth of 250 feet. It was unlikely that cement had set at that height because the cup packer had been set at 260 feet. Even if all the cement pumped (28.3 cubic feet) had remained in the casing, it would have filled only about 36 feet of casing, bringing the top of the cement it up to the 260-foot depth. The cause of the obstruction at 250 feet is unknown.

Cementing of the remainder of BW-2 went smoothly, as successive intervals were perforated and cemented. Perforations were cut with a hydraulic mills knife. In each case, the top of cement was tagged just above the perforated interval, indicating that the hydraulic pressure generated by the water being pumped through the cup packer was driving the cement through the perforations and into the gravel pack and formation. Because of the observed permeability of the formation, Flocele was added to each mix until the cemented depth interval of 133 to 179 feet. On that lift, the uppermost joint of tremmie buckled during the injection of water, as a result of the pressures being generated downhole. After that experience, Flocele was used sparingly.

On the next-to-last lift, cement was brought above the water table to nearly the top of the perforations. As the cement set up, all water in the casing drained out of the well into the formation. On the final lift, cement was pumped to within 12 feet of the ground surface. Cement wash water was pumped down the hole and was subsequently transported to the wastewater treatment plant for disposal. Later the casing was topped off to the floor surface with Pozmix. Because this well was contained inside a building in a concrete pad, it was not considered necessary to jackhammer the concrete and cut off the upper 3 feet of casing.

Base Well 12

BW-12 was abandoned between April 18 and April 24, 1991. The location of BW-12 is shown in Figures 2 and 9. Table 4 and Figure 10 summarize the cementing operations at the well. BW-12 was located in a subsurface vault at Building 395 with access through a trapdoor in the roof. BW-12 was constructed in 1943 with a 14-inch-diameter casing from the surface to a depth of 140 feet. From 140 feet to the bottom of the hole, a 12-inch-diameter casing was used. The television survey and tremmie pipe tagged the bottom of the well at 376 feet. The borehole diameter was unknown, but

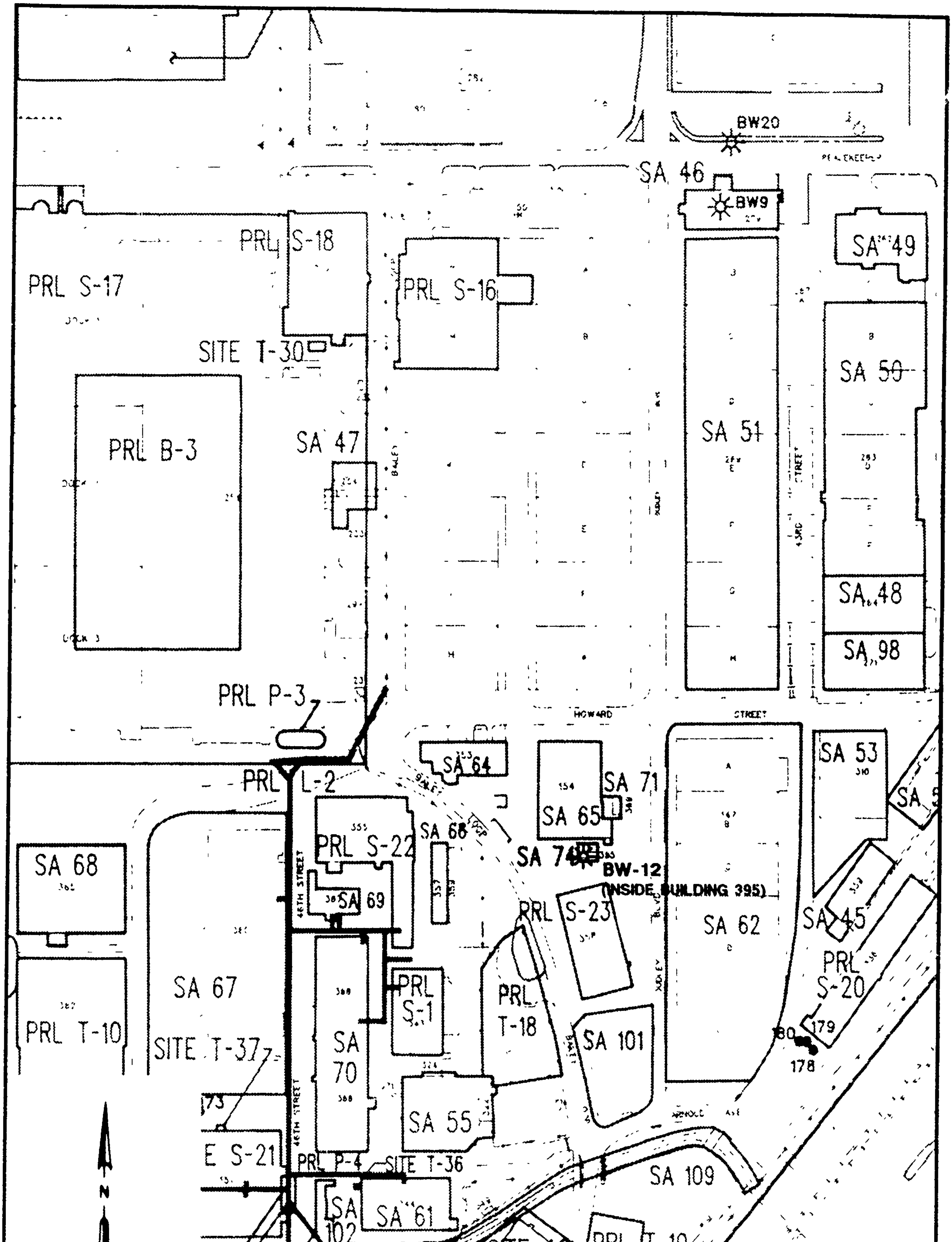

FIGURE 9
LOCATION OF BASE WELL NO. 12
McCLELLAN AIR FORCE BASE

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Table 4
Summary of Cementing Operations at Base Well No. 12

Perforated Interval (ft)	Depth Packer Set (ft)	Interval Cemented (ft)	Rise (ft)	Grout Formulation	Density (lb/gal)	Cement Volume (ft^3)	Cement Vol. Per Foot of Rise (ft^3/ft)
376-163 (existing)	N/A[a]	376-364	31	Standard Fine Cement 2% $Cacl_2$ 0.75% CFR-3	12.8	27.2	2.27
Same	N/A	364-313	51	Standard Fine Cement 2% $Cacl_2$ 0.75% CFR-3	12.8	87.2	1.71
Same	N/A	313-268	45	Standard Fine Cement 2% $Cacl_2$ 0.75% CFR-3	12.8	87.2	1.94
Same	N/A	268-250	18	Standard Fine Cement 2% $Cacl_2$ 0.75% CFR-3	12.8	87.2	4.84
Same	N/A	250-216	34	Standard Fine Cement 2% $Cacl_2$ 0.75% CFR-3	12.8	87.2	2.56
Same	N/A	216-188	28	Standard Fine Cement 2% $Cacl_2$ 0.75% CFR-3	12.8	87.2	3.11
138-90 (new)	N/A	188-135[b]	48 (12") 5 (14")	Standard Fine Cement 2% $Cacl_2$ 0.75% CFR-3	12.8	87.2	1.65
Same	N/A	135-108	27	Pozmix 2% bentonite 3% $Cacl_2$	14.1	56.2	2.08
Same	N/A	108-52	56[c]	Pozmix 2% bentonite 3% $Cacl_2$	14.1	247.1	11.47 1.07[d]

[a]N/A = Not Applicable
[b]Casing diameter enlarges from 12 inches to 14 inches at 140 feet
[c]Topped off with Pozmix
[d]Casing volume = 1.07 ft^3/ft

SAC/T183/004 51

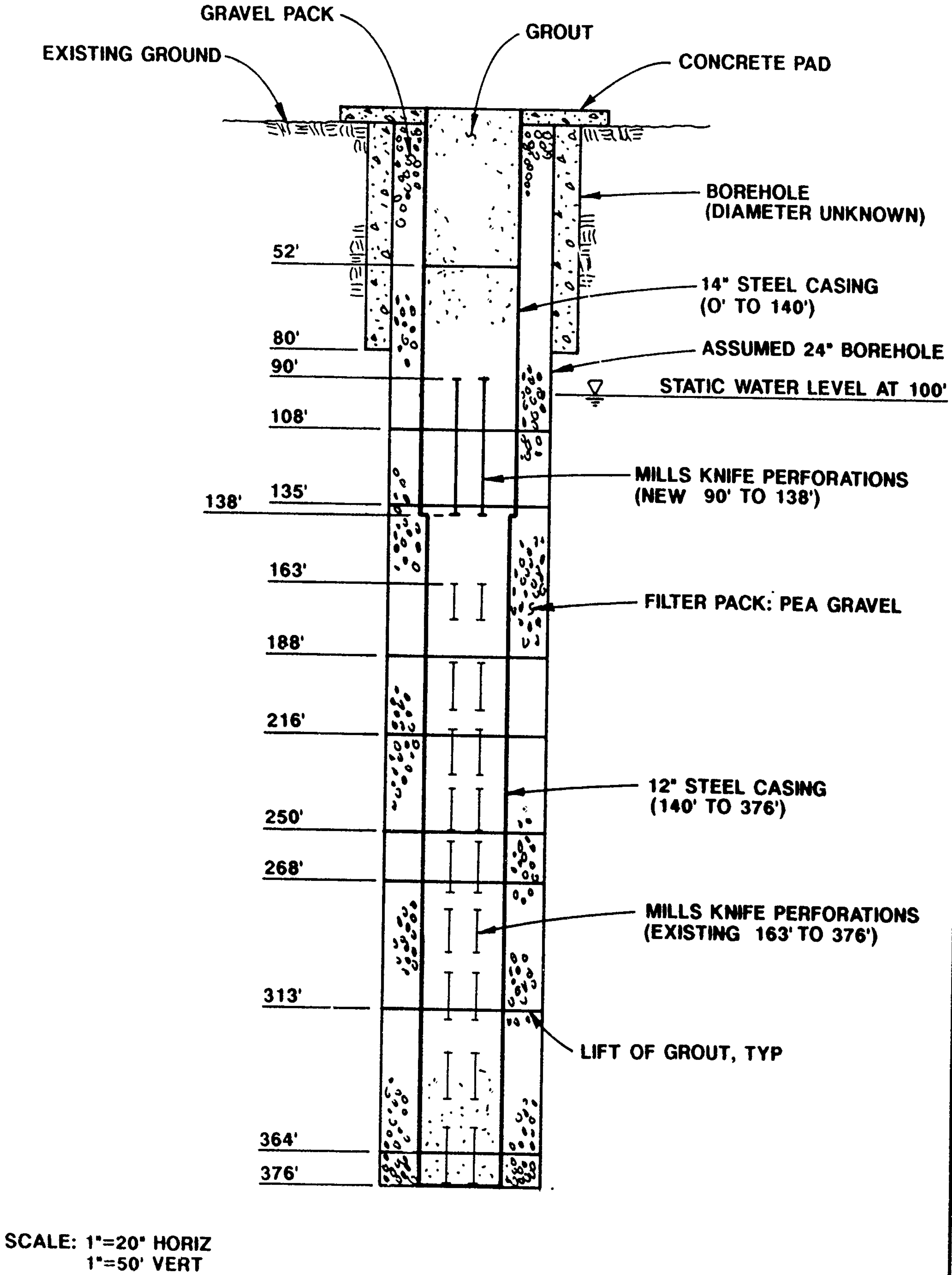

FIGURE 10
CEMENTING OPERATIONS AT BASE WELL NO. 12
McCLELLAN AIR FORCE BASE

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was assumed to be 24 inches. Existing perforations extended from the 163-foot depth to the bottom of the well. The formulation of the gravel pack was also unknown, but, because the well was constructed in 1943, it was assumed to be pea gravel. The volume of cement calculated to abandon BW-12 was 1.73 cubic feet of cement per foot of rise in the portion of the well with 12-inch casing and 1.90 cubic feet of cement per foot of rise in the portion of the well with 14-inch casing, assuming a 40 percent porosity; and 1.50 cubic feet of cement per foot of rise in the portion of the well with 12-inch casing and 1.69 cubic feet of cement per foot of rise in the portion of the well with 14-inch casing, assuming a 30 percent porosity.

The television survey conducted in BW-12 revealed that the casing was in an advanced state of deterioration, with holes, cracks, and splits extending throughout the length of the well. This fact, together with the fact that the well was already perforated through most of its depth, dictated that the packer method of abandonment could not be used. After consultation with Halliburton, it was decided to use Matrix Cement, which has the ability to flow into small pore spaces without additional pressure. This capability was enhanced by the addition of CFR-3.

The approach followed at BW-12 was very similar to the approach are followed at CW-150. The tremmie pipe was lowered to within about 10 feet of the bottom of the well. Water was injected through the pipe to confirm that the system was open and free of blockage. Next, a quantity of cement calculated to abandon the well in a series of short lifts was pumped. Following grout placement, the pipe was withdrawn, cement wash water was injected down the hole, and a head of water immediately placed on the well. Unlike at CW-150, the maximum flow of water obtainable from the nearby fire hydrant was insufficient to achieve a head of water all the way to the wellhead. However, the grout mix performed so well that the goals for grout placement were met or exceeded on nearly every lift.

After BW-12 was abandoned nearly to the top of the existing perforations, it was decided to perforate the casing to a point above the water table to make sure the uppermost zone of the well would be adequately sealed. Perforations were successfully cut from 138 to 90 feet with a hydraulic mills knife without collapsing the casing. The final lift using Matrix Cement brought the top of the cement to a depth of 135 feet. Because Halliburton had no more Matrix Cement on hand, Pozmix was used for the remainder of the well. Since most of the well had been sealed off, it was possible to put a full head of water on the cement. The next-to-last lift brought the top of the cement to 108 feet, with 2.08 cubic feet of cement per foot of rise plugging the gravel pack and formation.

The final lift was intended to bring the cement to ground surface, but after nearly twice the amount calculated had been pumped, the top of the cement was at 52 feet. Much of the cement was lost to a permeable zone that lay above the water table between 90 and 108 feet. Approximately 11.5 cubic feet of cement per foot of rise was required to fill this zone. The cement in BW-12 was topped off with Pozmix to the floor surface.

The successful abandonment of BW-12 served to refine the technique to be used in decommissioning wells that are perforated for great intervals, or contain weak or damaged casing. In these situations, use of a cup packer is not appropriate. However, a low-viscosity cement such as standard fine cement with a dispersant additive similar to CFR-3 was found to seal the well adequately. The well should be abandoned in stages, with water pumped into the well to supply additional driving force.

Base Well 1

Abandonment at BW-1 was started between April 24 and April 25, 1991, but was delayed because of problems. Abandonment continued from June 19 to July 26, 1991. The location of BW-1 is shown in Figures 2 and 11. BW-1 was located in Building 231, with access through a trapdoor in the roof.

The second television survey performed for BW-1 following the cleaning of the casing showed no indication of weakness or damage, so it was decided to employ the cup packer approach to abandonment. The cup packer was lowered in the casing in preparation for cementing. However, at 221 feet it hit an obstruction in the casing and could not be lowered further. This was not unusual, because the large-diameter packer had hit obstructions in other wells.

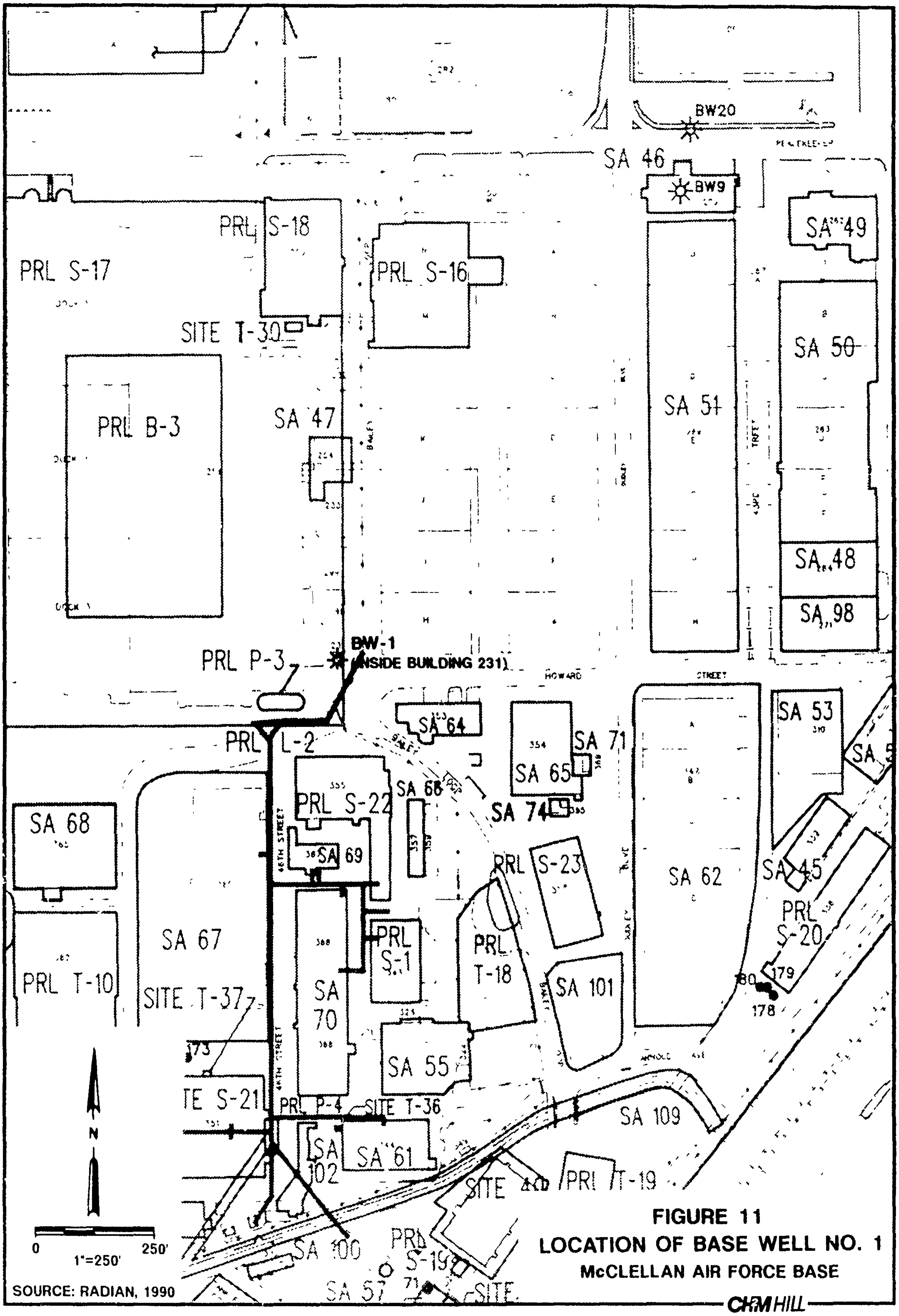
On April 25, the packer was dislodged and could have been lowered further. However, the crew dropped a weighted line down the hole and tagged an obstruction at 162 feet. This was believed to be sediment, because the packer could be lowered but not raised. The weighted line was then dropped through the pipe and cup packer, and was stopped again at 232 feet.

On April 26, another television survey was performed on BW-1, revealing no damage to the upper part of the casing. However, the camera contacted sediment at 162 feet and could not be lowered further.

It was thought that a hole or holes existed in the casing near or just below the 162-foot depth. Previous television surveys showed perforations in the casing from 158 to 174 feet, but no obvious damage. Layne-Western had perforated other portions of the casing (at 95 to 153 feet, 179 to 232 feet, and 300 to 340 feet) during a period of down time on CW-150. Perforations at BW-1 were made with a hydraulic mills knife, as at wells CW-150, BW-2, BW-12, and BW-27.

It was decided to remove the sediment and cup packer from BW-1 using an airlift procedure. Following this operation, BW-1 would continue to be abandoned as was BW-12 using standard fine cement. This work began on June 19, 1991.

The airlift involved installing 4-inch-diameter eductor pipe inside the casing next to the tremmie pipe and extending to the top of the sediment. An air line was connected to a large (195 cfm, 125 psi) air compressor and fitted down inside the eductor pipe. A discharge pipe line from the eductor pipe ran to a 25-yard-capacity portable steel bin. Water from a fire hydrant was pumped into the well to increase the submergence of the eductor pipe. Air pumped from the compressor caused aerated slugs of water to



SOURCE: RADIAN, 1990

FIGURE 11
LOCATION OF BASE WELL NO. 1
McCLELLAN AIR FORCE BASE

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surge in the casing, loosening the sediment, which then flowed up out of the eductor pipe into the bin. As the bin filled with sediment and water, a centrifugal pump was used to decant the excess water back down the casing.

Airlifting continued until the packer was freed on June 28, 1991. A television survey revealed holes and cracks in the casing from 164 to 192 feet and the top of additional sediment at 215 feet. Airlifting continued until July 10, when the bottom of the well was cleared of sediment. In all, two bins were filled about two-thirds full with material removed from the well. Nearly all of the material removed appeared to be pea gravel from the gravel pack, although some material may have been derived from a permeable zone near the water table. A small volume of fine-grained material was removed from BW-1, mainly derived from existing sediment at the bottom of the well. At the conclusion of airlifting, the top of the gravel was at 207 feet in the annulus around the casing, as tagged through the gravel feed tube.

The Halliburton crew arrived at the site on July 11, 1991, to continue the abandonment of the well. BW-1 was constructed in 1937 and was 396 feet deep with 12-inch-diameter casing. The borehole was listed as 18 inches in diameter, although the quantity of gravel pack removed from the well suggested that the borehole diameter was larger. Therefore, calculations for BW-1 were made using 18- and 24-inch-diameter borehole measurements. The volume of grout estimated to fill the casing and gravel pack in a 24-inch borehole was 1.73 cubic feet of cement per foot of rise assuming a 40 percent porosity, and 1.50 cubic feet of cement per foot of rise assuming a 30 percent porosity. The volume of grout estimated to fill the casing and gravel pack in an 18-inch borehole was 1.18 cubic feet of cement per foot of rise, assuming a 40 percent porosity, and 1.08 cubic feet of cement per foot of rise, assuming a 30 percent porosity. The borehole annulus around the casing was empty from 207 feet to the surface. The volume of grout estimated to fill this space was 3.14 cubic feet of cement per foot of rise assuming a 24-inch borehole, and 1.77 cubic feet of cement per foot of rise assuming an 18-inch borehole.

Table 5 and Figure 12 summarize the cementing history at BW-1. The lower 268.5 feet were grouted with 300 sacks (591 cubic feet) of Matrix Cement with calcium chloride and CFR-3. This brought the top of the cement to 127.5 feet and required five lifts. Difficulty was experienced during cementing of the uppermost zone of the well near the water table. At 127 feet, all the Matrix Cement on hand had been used, so Pozmix was used to fill the remaining portion of BW-1. The lift from 127.5 to 113 feet required 102 cubic feet of cement for a volume of 7.1 cubic feet of cement per foot of rise. The lift from 113 to 111 feet required 99 cubic feet of cement per foot of rise. At that point, it was obvious that cement was being lost to a permeable zone in the formation above the water table. Although use of the cup packer was planned for the last lift, it was decided to pump Pozmix without the packer and to add Flocele to control losses to the formation. The next lift, from 111 to 96 feet, required 92.4 cubic feet of cement, an unacceptably high volume of cement.

Table 5
Summary of Cementing Operations at Base Well No. 1

Sheet 1 of 2

Perforated Interval (ft)	Depth Packer Set (ft)	Interval Cemented (ft)	Rise (ft)	Grout Formulation	Density (lb/gal)	Cement Volume (ft^3)	Cement Vol. Per Foot of Rise (ft^3/ft)
396-378 (existing) 356-345 (existing) 340-300 (new) 296-278 (existing)	N/A[a]	396-275	121	Matrix 2% Cacl$_2$ 0.75% CRF-3	12.7	217.8	1.80
275-268 (existing) 257-252 (existing) 241-237 (existing)	N/A	275-231	44	Matrix 2% Cacl$_2$ 0.75% CRF-3	12.7	79.2	1.80
232-179 (new)	N/A	231-193	58 (24 pack) (14 open)	Matrix 2% Cacl$_2$ 0.75% CRF-3	12.7	87.2	1.80 3.14[b]
174-158 (existing)	N/A	193-162	31	Matrix 2% Cacl$_2$ 0.75% CRF-3	12.7	97.3	3.14[b]
153-95 (new)	N/A	162-127.5	34.5	Matrix 2% Cacl$_2$ 0.75% CRF-3	12.7	108.3	3.14[b]
Same	N/A	127.5-113	14.5	Pozmix 2% Gel 3% Cacl$_2$	14.1	102.3c	7.06[b]
Same	N/A	113-111	2	Pozmix 2% Gel 3% Cacl$_2$	14.1	99.0	49.50[b]
Same	N/A	111-99.5	11.5	Pozmix 2% Gel 3% Cacl$_2$ Flocele	15.0	92.40	8.03[b]
Same	N/A	99.5-94.5	5	Class G Cement 8% Gel Cal Seal 2% Gel 2% Cacl$_2$	15.6	37.7	7.54[b]
153-95 (new)		94.5-93	1.5	Pozmix 2% Gel 3% Cacl$_2$ Flocele	14.1	110	73.33[b]

SAC/T183/005 51

Table 5
Summary of Cementing Operations at Base Well No. 1
Sheet 2 of 2

Perforated Interval (ft)	Depth Packer Set (ft)	Interval Cemented (ft)	Rise (ft)	Grout Formulation	Density (lb/gal)	Cement Volume (ft^3)	Cement Vol. Per Foot of Rise (ft^3/ft)
N/A		93-54 (annulus) 93-51 (casing)	39 42	7-Sack Sand Mix	?	81 (annulus) 27 (casing)	2.08 (annulus) 0.64 (casing)
N/A		54-Surface (annulus) 51-Surface (casing)	54 51	Types I and II Cement 4% Bentonite	?	102 sacks 24 sacks	2.35 (annulus) 0.79 (casing)

[a]N/A = Not Applicable
[b]Empty annulus above 207 feet

SAC/T183/005 51

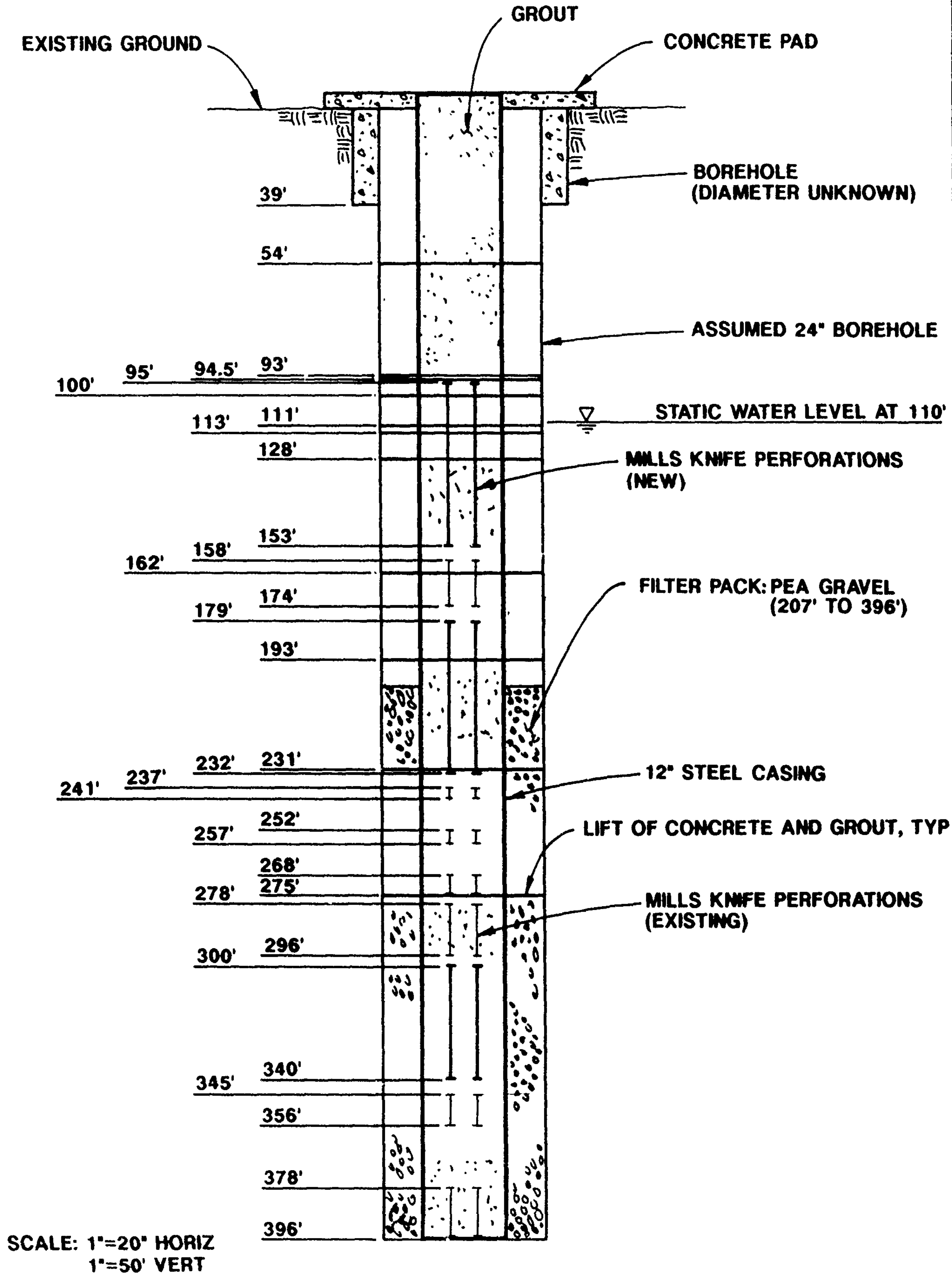


FIGURE 12

CEMENTING OPERATIONS AT BASE WELL NO. 1

McCLELLAN AIR FORCE BASE

CH2M HILL

After consultation with Halliburton, it was decided to add 8 percent Cal-Seal to the Pozmix to achieve a quick set and seal off the zone. However, this provided a gain of only 7.5 cubic feet of cement per foot of rise in the hole, bringing the top of the cement to a depth of 94.5 feet. Because the static water level was originally at about 110 feet, it was determined that the cement was being lost to the vadose zone. On the next lift, Pozmix with Flocele was used again. After 110 cubic feet of cement was pumped into the well, the tag revealed that the top of the cement had only come up to 93 feet.

The abandonment of BW-1 was stopped because of the high cement losses being incurred. The Air Force and DHS then authorized the use of a sand cement mix to seal off the permeable zone. Research of available geophysical logs taken during construction of nearby monitoring wells revealed the top of the permeable zone would be reached at a depth of 60 feet. On July 24, 1991, a ready-mix truck was brought to BW-1, and a seven-sack sand cement mix was pumped with a cement pump into the well. About 3 yards of cement was pumped into the annulus through the gravel feet pipe. Next, 1 yard of cement was pumped into the casing. After the cement set up, the top of the cement was tagged at 54 feet in the annulus and 51 feet in the casing. Sand cement was also used to top off wells BW-27 and CW-150. Finally, neat cement (Type II) with bentonite was used to fill the annulus and casing to the floor surface.

STATUS OF PRODUCTION WELLS AT McCLELLAN AFB

Altogether, 29 known water wells were identified in McClellan AFB files. Over the years of operation, McClellan AFB has acquired land with existing wells and has constructed new water supply wells. Locations of the wells are shown in Figure 2. Wells BW-1, BW-2, BW-12, and BW-27 have been decommissioned. Wells BW-3, BW-6, BW-16, and BW-19 were originally scheduled for decommissioning, but could not be located in 1990. BW-3 and BW-19 were thought to be in the southwest part of the base near Buildings 662 and 663 at the intersection of Bell Avenue and Kilzer Avenue. A recent field inspection discovered what appears to be two former wells in a field about 200 yards west of the Bell/Kilzer intersection. One well contains a 14-inch-diameter steel casing, the other a 6-inch-diameter steel casing. Both extend a few inches above the ground surface and are filled with concrete. BW-6 is thought to be located near the west boundary of the base, near Patrol Road in the vicinity of Buildings 714 and 715. According to base personnel, it may be an old agricultural well. BW-16 is located in the southeast area of the base, south of Building 440 near Dudley Boulevard. This 10-inch-diameter well was recently located in a parking lot across the street from Building 440. Of these four wells, limited data are available for BW-19 only. This well was reportedly constructed in 1952 with a depth of 360 feet. Perforations extended from 174 to 193 feet, 214 to 239 feet, and 305 to 360 feet. BW-19 is said to have collapsed (LSCE, 1984).

No information is available for five wells on the base: BW-14, BW-21, BW-22, BW-23, and BW-24. BW-14 has no known location on the base. BW-21 is reported to be in the southwest area of the base, near Building 689 along Kilzer Avenue. BW-22, BW-23, and BW-24 are apparently old agricultural wells added during land acquisition at McClellan AFB. A field check did not reveal the location of these wells, but they are reported to be in the northeast area of the base. BW-22 is reported to be near Building 1445 in the extreme northeast corner of the base, BW-23 near Building 1045 along Price Avenue, and BW-24 near Building 1436 at Dudley Boulevard.

Five wells are located off McClellan AFB property. BW-5, BW-25, and BW-26 are presently operating and supporting off-base facilities operated by the Air Force. BW-11, just southeast of the base, was operated as a supply well for the base until 1985, when it was taken offline by a contractor as part of a property transaction. BW-15 is thought to be on the corner of Whitney and Eastern Avenue, but no construction details are available. This well is currently inactive.

The remaining wells are summarized in Table 6. Wells BW-4, BW-7, BW-8, BW-9, BW-13, BW-17, BW-20, and BW-28 are either inactive or on standby. Wells BW-10, BW-18, and BW-29 are the only supply wells in active production at this time.

RECOMMENDED ABANDONMENT APPROACH

Two main approaches were most successful in properly abandoning wells at McClellan AFB. One approach, application of a downhole squeeze utilizing a cup packer, is a low-cost method applicable for wells screened intermittently along the length of the casing with casing that is capable of withstanding the hydraulic pressures generated by the packer. The other approach, special low-viscosity cements and application of a head of water, is a more expensive method that is applicable for wells screened continuously along the length of the casing or those that contain weak or damaged casing. Both approaches call for the well to be cemented in stages, with external pressure applied to the cement to force it into the gravel pack.

Future abandonment efforts should be directed at other wells at McClellan AFB. Former production wells that may be considered for decommissioning include the four wells originally scheduled for decommissioning during this phase that could not be located (BW-3, BW-6, BW-16, and BW-19). As previously mentioned, BW-3 and BW-19 may now have been located in a field on the southwest base boundary. BW-16 has been located south of Building 440 along Dudley Boulevard. In addition to BW-6, other base wells have not been located in the field. These include BW-14, BW-21, BW-22, BW-23, and BW-24. Records searches and interviews, combined with magnetometer surveys, should be employed to locate the remaining wells.

McClellan AFB should also evaluate for abandonment other production wells that are presently inactive. These include BW-4, BW-7, BW-8, BW-9, BW-13, BW-17, and

Table 6 Summary of Existing McClellan AFB Production Wells						
Well No.	Location	Depth (feet)	Casing Diameter (inches)	Perforated Intervals (feet)	Depth of Seal (feet)	Comments
4	Southeast near Winstead Athletic Field	382	12	169-382	81	Inactive
7	Southwest near Building 489	398	12	170-398	50	Inactive due to phenol contamination
8	Southeast near Building 20 on Arnold Avenue	800	10	Unknown	43	Went inactive in 1985 due to high iron and magnesium
9	Near Building 209 on Peacekeeper Way	660	14	Unknown	Unknown	Collapsed and replaced by BW-20; records show no abandonment
10	East near Building 93 on O'Malley Avenue	400	14" to 144'; 12" to 400'	170-392	Unknown	Active well
13	South base area, south of Building 614	391	14" to 147'; 12" to 391'	178-391	50	Inactive since 1988 due to carbon tetrachloride
17	Southwest in Building 699 on Kilzer Avenue	390	16	216-224 286-294 302-312	Unknown	Went inactive in 1985 due to TCE; has been partially filled with sand
18	Southwest near Building 664 on Winters Street	408	14	169-185 210-260 304-349 378-387	50	Active well
20	South of Building 200 on Peacekeeper Way in southeast of base	600	14	178-190 234-274 338-374 494-506 564-598	Unknown	Standby source for Building 200
28	North base area, to east of Building 1082	247	8	144-147 205-212 233-236	60	Inactive
29	North area, in Building 1455 on Perrin Avenue	604	16	251-401 401-555	53	Active well, Old BW-29 was abandoned in 1984 due to sand; new BW-29 drilled just north of former site

BW-28. These wells, excluding BW-4 and BW-28, are described by base personnel as inactive because of groundwater contamination. McClellan AFB should decommission these wells to prevent potential aquifer cross-contamination. Finally, unused monitoring wells and boreholes drilled during previous geophysical investigations should be evaluated for abandonment. This section describes the steps that should be followed during future well decommissioning activities at McClellan AFB.

PRELIMINARY ACTIVITIES

Preliminary activities, both research and field work, must be accomplished at each well selected for decommissioning. Research involves gathering data on well construction details, hydrogeology in the immediate vicinity of the well, and groundwater quality. For abandonment, important well construction details include the diameter of the casing and borehole, gravel pack composition, depth of the well, age of the well, and depth intervals of existing perforations. Hydrogeologic data are helpful in locating permeable zones that may cause cement losses to the formation. Useful sources for this data include geologic and geophysical logs obtained during the drilling of nearby monitoring wells. In addition, groundwater quality data are needed to provide for personnel safety.

Preliminary field work includes removing existing pumps from the well, performing a downhole television survey, rehabilitating the well if necessary, and conducting a second television survey. The purpose of the first television survey is to evaluate the condition of the casing before cementing. Attributes to be noted include depth intervals of existing perforations, depth of the well, the presence of obstructions or encrustations in the casing or fill material in the bottom of the well, and the ability of the casing to withstand cementing pressures, as indicated by the presence of cracks or holes, and corrosion along the slots. Many of the wells at McClellan AFB will require additional work prior to cementing. Lubricating oil floating on the water should be bailed. Wells containing iron bacteria, which obscure the casing, should be cleaned with a steel brush, followed by bailing to remove debris and fill material. A second television survey should then be performed to evaluate the casing.

ABANDONMENT WITH A PACKER

Wells that are perforated at intervals along the casing and judged to be capable of withstanding high pressures, based on television survey evaluation, are suitable for cementing using a cup packer. Grout may consist of portland cement with additives to improve performance. At McClellan AFB, the grout mix that worked well consisted of API Class H cement, pozzolans, 2 percent bentonite gel, and 3 percent calcium chloride. This grout should be pre-mixed dry at the plant, and mixed with water at the job site. The steps in abandoning with a packer are as follows:

- Perforate the casing immediately prior to cementing if necessary.

- Set the cup packer in a blank section of casing above the interval to be cemented. Chain the tremmie pipe down evenly at the wellhead.

- Calculate a volume of cement necessary to fill the casing and 40 percent of the gravel pack to a point about 2 feet above the perforated interval.

- Calculate a volume of water necessary to fill the casing above the cement and below the cup packer, plus the entire tremmie pipe, and all surface piping downstream from the volume gauge.

- Pump a sufficient amount of water into the well to establish circulation and estimate the permeability of the formation.

- Mix the required volume of grout with a recirculating mixer to the desired density. Collect a sample and set it aside in the shade.

- Pump the required volume of grout with a positive displacement pump. Monitor the injection rate (less than 20 gpm) and the pressure (less than 100 psi).

- Pump the required volume of water slowly (less than 20 gpm) and monitor the pressure (less than 100 psi). Watch the tremmie pipe and chains for possible buckling. This is especially important in wells with large-diameter casing.

- Withdraw the cup packer from the well immediately to prevent it from being cemented in place.

- Inject cement wash water into the well.

- Tag the cement in the well with a weighted line after the cement sample sets up (minimum of 3 hours).

- Perforate the next interval, if necessary.

- Cement the well in a series of lifts. The length of the lift is determined by the length of existing perforations, the expected lithology, and the outcome of the previous lift.

On the next-to-last lift, the casing should be perforated about 15 feet above the water table.

The cement volume should then be calculated to bring the top of the cement to about 1 or 2 feet above the water table. As the cement sets up, water should drain out of the casing into the formation above the water table. This avoids the need to dispose of potentially contaminated water. On the final lift, cement should be brought to within 5

to 10 feet of the ground surface. It will be necessary to pump cement wash water into a tank trunk for disposal on the final lift. The earth should be excavated and the casing cut about 3 feet below grade. Finally, the cement should be topped off to the ground surface. All equipment should be steam-cleaned before use at the next well.

ABANDONMENT WITH LOW-VISCOSITY CEMENT

A different approach is necessary in wells that are perforated continuously for great lengths or that contain casing that is judged too weak to sustain the pressure generated by use of the cup packer. Setting a cup packer within a perforated zone is pointless because the closed piston necessary to generate hydraulic pressure may not be obtained. Setting a cup packer within a zone of weak casing risks casing collapse or may cause holes to open, thereby allowing sediment to flow into the well.

In this situation, the best approach is to cement the well in a series of lifts using a low-viscosity cement. At McClellan AFB standard fine cement with the addition of CFR-3 was found to work well. The tremmie pipe should be set about 10 feet off the bottom, and water circulated down the hole prior to cementing. After the cement is pumped, an attempt should be made to apply a head of water to the well. At McClellan AFB, the static water level is about 90 to 100 feet below the ground surface. A head of water provides about 45 to 55 psi of pressure, which is transmitted directly to the top of the cement. It may not be possible to maintain a full head during the early stages of abandonment because the water will be lost to the formation. As the well is cemented off, however, it becomes easier to apply the head. Success with this method is observed by comparing the calculated top of cement for the volume pumped with the actual top as measured by the tag.

REFERENCES

CH2M HILL, 1991. Well Closure Methods and Procedures. Prepared for McClellan Air Force Base.

Halliburton Services, 1981. Halliburton Cementing Tables. Little's, Duncan, Oklahoma.

__________, 1985. Sales and Service Catalog.

Luhdorff and Scalmanini Consulting Engineers, 1984. Sealing of Base Wells, McClellan Air Force Base, California.

Radian Corporation, February 1990. Preliminary Groundwater Operable Unit Remedial Investigation (Hydrogeologic Assessment) Sampling and Analysis Plan.

Radian Corporation, July 1990. Map: McClellan AFB Well Locations.

Appendix A

FIELD NOTES

From Page No.

Feb. 4, 1991 - Rob Pexton

Capt. Fran Slavitch 643-1250 or Jerry Robbins Hydro
or Alexe or Doug McKenzie
Hot Permit 643-5364

Layne Western - Tom Dea Sales Engineer

Pump Rig operator Henh De Wet
Helpers Alfonso Vela and Brian

11:30 Held safety meeting at Well 12 before starting work. calibrated meters.

Started work on Well 12 - took 3 photos before starting
Inspected Well 1 and Well 2. - both

1:15 Removed electric motor from pump shaft - Henh remarked it was quite old but very well built with more steel in it than is now used - photos 5-9. removed drive shaft to auxillary generator.

3:00 Attempting to pull pump discharge fitting, column pipe and pump bowls - unable to lift it. Estimated weight 2,000 lb for discharge elbow and fittings, 1000 lbs per 20 feet of column pipe = 7,000 lbs. plus 2,000 lbs for pump bowls ≈ 11,000 lbs
Crane Capacity ≈ 12-13 000 lbs - can't pull pump - it is loose and can be jiggled side to side slightly.

3:50 Move rig closer to well after cars moved out of parking lot - rig capacity now 16,000 lbs but they still can't pull the pump. they will try later with a SMEAL 25,000 lb capacity rig or a 50,000 lb capacity rig.
note No H-Nu, Explosimeter or rad-mini readings above background levels all day

4:00 Cleaned up - set up cones and flagging to work on Base well #1 tomorrow - parked rig at staging area which Radian + Universal Engineering use. Fran Slavitch will be out tomorrow and is arranging to get the key to wells 1 and 2. Layne Personel in Woodland also

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	2/4/91	Recorded by	

TITLE BW-12

Project No.

Book No. BW-12

From Page No.

ll #1 ASA 200 Print film Feb 4, 1991

PHOTO #	LOCATION	
1	Well 12	before removing pump
2	"	
3	"	
4	"	
5	"	Pulling Motor off
6	"	"
7	"	"
8	"	Pulling mounting bracket for motor off
9	"	"
10	"	
11	"	
12	"	Attempting to pull pump column pipe and discharge elbow
13	"	
5/91 14	Well 1	Motor and discharge assembly from inside pumphouse
15		" "
16	Well 2	Motor + discharge assembly from inside pumphouse
17	"	"
18	"	From south side of building showing discharge piping
19	Well 1	from outside with pump rig
20	Well 1	Removing pumphead shaft bearing etc
21	"	
22	"	Looking inside discharge elbow to pump shaft
23		
24	"	Breaking first Joint of column pipe

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	2/4/91	Recorded by	

Feb 5, 1991

:00 Setting up meters in office

7:30 On base - Pump crew at well 1, - Went to get key from Doug McKenzie
pump is very similar to pump at well 12 - water cooled motor on a stand
≈4 feet above discharge coupling.
Well 1 is at Corner of Bailey Loop and Howard St
Pump crew removing motor motorstand + gear drive. Doug McKenzie said to wait on
DMRO paperwork until we had some pumps pulled and stored at the staging area.

:45 Recieved Welding Permit for Base Wells 1, 2, and 12 From Base Fire Dept.

0:00 Pulling pump - assembly lifts o.h. - appears heavy. Well records indicate
160 feet of 10" column pipe with bowls on the bottom. However
the column pipe is actually 8".
The well is screened ≈152 - 176 and the pump bowls are at 160 - 164?
which indicates the bowls and intake are set in the well screen.

H-Nu Explosimeter and Rad Mini read at background levels when pulling pump head.

:00 Breaking first joint of column pipe (10' pipe)

:00 Lunch Break 15 min - 40' of pipe out - Spoke with Doug McKenzie about delivering
the pump to DMRO - the person in charge at DMRO was out until 7:30
tomorrow - I made a list of the ≈ 7 tons of equipment which makes up the
pump so DMRO would know what to expect - Hopefully we can transfer
the pump column directly to DMRO instead of droping it at a staging area.

3:00 Pulled 120 feet of column pipe - started to get hydraulic oil at ~~100~~ 110
feet where static water was. Above that the pipe was oil free due to the
pump being inactive for 10 years. The 8 inch colum pipe was a 3/8" per foot
taper for the first 90 feet and is 3/16" per foot taper butt fitting
threaded pipe below that - The drive shaft is dated July 27, 1957.
The shaft has bearing wear marks on it indicating that the
pump had been maintained and the ~~sha~~ 10' drive shaft sections
turned around at some ~~past~~ time. Hinh ~~Vo~~ De Wet thought the
motor and mounts were probably pre war. The change from taper to
butt pipe suggests that the pump setting was lowered at some time

Witnessed & Understood by me, | Date 2/5/91 | Invented by | Date | Recorded by

From Page No.

Roll # 2

1. Well 1, Breaking first joint of Column pipe close up
2. " Pump head and first 10' joint of column pipe being lifted out of well
3. " Breaking oil column "
5 " Breaking 1st line shaft joint "
6 " " "
7 " Lifting pump head and column pipe up out of pumphouse
8 " Laying pump head and first 10' column pipe on the ground
9 " Breaking 2nd joint of column pipe
10 " " "
11 " Breaking 2nd joint of oil tube
12 " "
13 " Breaking column pipe
14 " "
15 " Breaking bowls
16 " "
17 " Pulling bowls
18 "
19 " Pulling suction tube below bowls
20 "
21 Dropping off pump at DRMO Building 700
22 ~~Well 2~~ ~~torch cu~~ "
23 Well 2 torch cutting column pipe
24 " loading torch cut column pipe on flat bed
25 " loading bowls and suction pipe on flat bed

well 1
10 - All of Pump column (160' of 8" column pipe), pump bowls ≈ 10' and suction tube and screen ≈ 18'

To Page No.

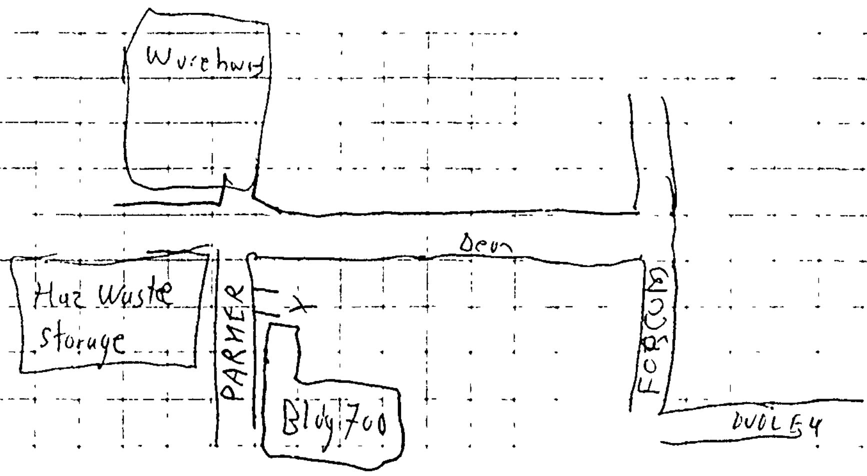
Witnessed & Understood by me, | Date 2/5/91 | Invented by | Date | Recorded by

From Page No. Feb 6, 1990

Stella HART 643-3943

DRMO - is Bldg 700

marketing office.



Go to recieving entrance (left) at bldg 700 J.

Al Garner (R) in charge of yard.

Sid Hall - Forman in 700 A. - I spoke with ~~Mr.~~ Sid who instructed me to bring the pump into recieving and to meet Al Garner to drop the pump off.

Pump was delivered to DMRO

SERIAL NUMBERS FOR PUMP FROM WELL NUMBER 1

PEERLESS PUMP SERIAL NUMBER J10211 - for pump head + discharge elbow

US MOTOR SERIAL NUMBER 342345

100 HP 440V 3 Phase 127 A 1800 RPM at 60 Hz

FRAME No. 982 A

US Electrical Motors Inc.

PEERLESS GEAR TURBO (Gearbox) SERIAL NUMBER J8113 - FMC-Los Angeles Ca

GEAR RATIO 6A2-3 by FMC

recommended turbine oil 600 second viscosity at 100°F

66 " 210°F

PUMP BOWLS - 6 stage 10" bowls by Verti-Line AURORA PUMPS

SERIAL # V76-72757 TYPE 12RML City of Industry, Ca

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	2/6/91	Recorded by	

From Page No. Feb 6, 1991

To get on Catalog mailing list - go to Sales and Reutilization office

- Catalogs for sealed bid sales will be sent

- The pumps will be sold as a sealed bid Scrap lot - buyer needs to be on a sealed bid sales list.

Bldg 232

1:00 Setting up at Well No 2 - Well taken out of service November 23, 1979.

~~Peabody~~ FLOWAY PUMP - No SERIAL Numbers on name plate
FIESE & FIRSTENBERGER MFG CO FRESNO, CA, USA

GENERAL ELECTRIC MOTOR - TRICLAD INDUCTION MOTOR Schenectady N.Y
SERIAL NO. SPJ 521605
MODEL NO 5K405XC54A 50HP ~~440~~ 220/440V 120/60 Amp at 60 Hz
1765 RPM

note - could not find serial Number or make on pump bowls

Note: Layne is replacing the second helper with Eric ? who will be on site this afternoon.

Layne Log from Feb 4

9-11 - Getting passes + Paperwork on base
11-16:00 Start pulling pump - well 12 - pump stuck
16-16:30 Pick up + secure site

Layne Log Feb 5

7:15 on site
7:30-17:30 Pull pump 160' 8" x 3" x 1 1/16" plus 6 stage bowls plus 10' suction
17:30-18:00 Clean up - secure site.
12:30 - Chuck Elliott on site. I spell Rob for the afternoon.
2:00 removed electric motor - detected 4ppm on HNU.
3:20 HNU = 20ppm along pump column. Breathing space = 2ppm.
Decided to wait 5 minutes, then monitor again.
3:25 HNU = 12ppm downhole; 2-3 ppm in breathing space

To Page No. 7

Witnessed & Understood by me, Date 2/6/91 Invented by Date Recorded by

From Page No.

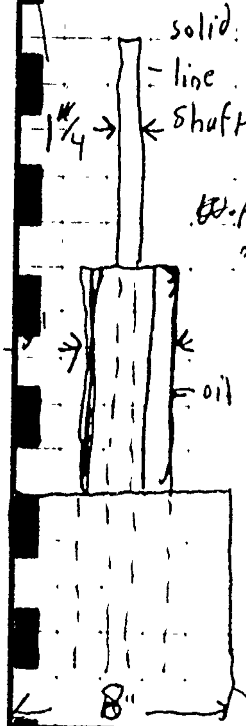
3:30 Decide to condense. Proving necessary to torch column - Sections rusted shut, impossible to unscrew.
4:30 Begin packing up for the day.
4:45 Leave site.

Feb 7, 1991

7:00 Drillers arrive + start setting up - start pulling sections of pump column still necessary to ~~cut~~ torch cut the column pipe at each joint down to the water table at 100 feet BGS. At 100 feet the column pipe changed from 3/8"/foot taper pipe to 3/16"/foot taper butt joint pipe which would unscrew - remaining joints below water table unscrewed successfully.

No H-Nu, explosimiter or rad-mini readings were found either at the well head or in the breathing zone. I checked the H-Nu by placing it next to the acetylene torch while releasing acetylene. This immediately pegged the meter on the 0-20 ppm scale. ~~Therefor~~ Acetylene is also heavier than air so it might have been what Chuck found with the H-Nu yesterday. Another possibility is that they burned up one of the plastic straps which held on the air line just before the higher readings were taken and the fumes from burning may have activated the H-Nu meter

might be 1 5/16



~~W.~~ Pump column pipe ~~is~~ standard setup is 10 x 20 which means that the ≈2" dia oil column joint is 10" above the ~~column~~ 8" diameter column pipe joint and the ≈1 1/4 solid drive shaft joint is 20" above the column pipe joint. The distances have been variable on this well #2, indicating the shaft may have been modified or a piece of column pipe is short.

The pump had 15 pieces of 10' x 8" x 2" x 1 1/4"
1 - 6 stage bowl assembly (10')
1 10' suction tube and screen

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	2/7/91	Recorded by	

From Page No. Feb 8, 1991

9:45 Layne arrives at Well 12 with their 50 ton pump rig, which has a third leg which pivots out from the Derrick

SPEEDSTAR MODEL WS-50

made by Speedstar Division of Koehring Co. Enid Oklahoma 73701

They also are using the pump rig they've had all along, with a JLG Model 1250 RT Crane with a maximum lift of ~20000 lbs 7 feet from the crane pivot.

10:00 The pump come free quite easily with the Speedstar WS-50 rig pulling in 4th gear (relatively low torque). The column pipe is 10" in a 12" well casing which is a tight fit. Layne is chiseling out some concrete below the pump head to give a flat surface to work of for removing the pump joint by joint. Heath DeWet estimates they will pull 60 feet of column pipe today.

H-Nu Explosimeter and rad mini measured ∅ at the wellhead and in the breathing zone after lifting the pump ≈ 2 feet.

Photos of setting up WS-50 rig and breaking pump loose

Roll 3

16 Well 12 Setting up WS-50 Rig to pull pump
17 " "
18 " pulling pump - 10" column pipe in 12" well casing.
19 "
20 "
21 "
22 "
23 " Laying column pipe out on deck
24 "
25

12-12:30 Lunch

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	2/8/91	Recorded by	

TITLE Bw-12 Project No. Book No. Bw-12 9

From Page No. Well 12 Feb 8

1:30 - Move 50 ton SPEEDSTAR RIG off site.
3:30 . 80 feet of column pipe removed

Henh notes that the well is very crooked and he has to move the derrick boom around on each 10' length of pump column to center it in the well

The 10" ~~casing~~ pump column is a tight fit in a 12" well (standard practice would be 10 inch pump column in a 16" well) The ground here may have settled some since the 1930's when the well was drilled as the water table may have dropped around 50 feet. They may not have had plumbness and alignment requirements in the 1930's city

Pump collum is 10" x 3" x 1 11/16"
column pipe oil tube lineshaft
all butt joint stainless steel
3/16"/foot taper
oil tube - line shaft bearings in good condition
(Note. bearings on well 2 were badly worn in some cases)

No H-Nu exsplosmeter or radmini readings above background today.

4:00 Clean up site. 90 feet of column pipe removed (10' + 10" x 3" x 1 11/16")
will finish on monday Feb 11

To Page No.

Witnessed & Understood by me, | Date 2/8/91 | Invented by | Date
Recorded by

From Page No. Feb 8

Roll 4 - Kodachrome Slides

10 Well 12 breaking column joints etc
14 Lifting a section of column pipe out

25 pump parts in salvage yard

Feb 11, 1991

09:00 Arrive onsite - Henk and Alfonso are nearly finished pulling Bw-12. ~~Hydraulic~~ lube oil is dripping off column.
9:45 I go to find Capt. Slavich and discuss disposal of pump parts at DRMO. He's unavailable, in a meeting. I decide to return and attempt to deliver pump parts to DRMO + do paperwork later. 10:00 Find Slavich + get copies of forms
11:15 Go to DRMO + unload pump column for Bw-12.

{ DRMO - Building 700-J
Attn: Scrapyard } After having chemical analyses made of lubricating oil (prior to disposal) I will send copy of results to ↖.

Well # 12

Peerless Pump: Serial No. T6939 (pump head)

GE Induction Motor Serial No 12F4516
100 HP

12:00 Finish unloading pump parts. Do paperwork with Henk.
12:15 Leave site.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	2/8/91 2/11/91	Recorded	

TITLE Bw-2 Book No. 11

From Page No.

Feb 12, 1991

7:00 Am Rob Paxton met Dave Locherby of WELENCO at Palmgate and went to Base Well 2 to video log it. - Dave Parked his van NW of the well and ran cable in through the door to the Building 232 and hung it from a pulley

8:00 Set up to log Well 2 - ≈300' deep screened 100-112, 141-158, 180-197, 282-296'

Photo	
17	Welenco truck
18	setting up in well 2
19	"
20	Video display in van
21	Casing slots

θ Well 2

0 -	Blank Casing in good condition. - camera set up at ground level
17 + 35	weld
57	~~w~~ weld.
75	Weld.
95	weld
96 - 106	Vertical slot
107	Fluid surface some oil on surface - very little - only a film
≈ 108	- Perforations stopped.
108 - 136	Blank casing in g
134	weld
136 - 153	Clean vertical slots about 6" × 1/4"
148 - 150	Pitting on one side of casing
153 -	Blank Casing. - clean
167	? Bacteria on casing - Camera brace hit bacteria

To Page No.

Witnessed & Understood by me, | Date 2/12/91 | Invented by | Date | Recorded by

174 ~~178~~-191 Plugged perforations ~ Vertical slots

191 - 274 ~~190? Badly corroded or bacteria~~
~~Lots of~~ encrustation on casing - typical amount according to Dave Locherby

273 Welded joint
274-286 Vertical slot perforations - hard to see perforations - heavy encrustation
282 heavy encrustation

286-7 ~~Bottom of well~~ Picture goes dark
288 Bottom of Well

No significant damage to the well noted on the way down by Dave Locherby

Note - Only a film of oil on the water surface probably because the water surface is in a perforated zone, the oil which would normally be on the surface of the water may be spread out into the formation on the water surface.

This well 2 was taken out of service November 23, 1979

A Well record form was maintained in Bldg 232 next to the well through December 1990.

If this well was to be used as a water well in the future one could use an energet to clean the perfs. by detonating a gas generating substance to force water through the perfs.

Witnessed & Understood by me, | Date 2/12/91 | Invented by | Date
Recorded by

From Page No.__

10 00 Arrive at Bw-1. Dave Lockerby of Welenco is setting up to run video log.
10 20 Run log. Casing welds at 20-ft intervals:
Oil appears to be about 1-ft thick on top of water. (Dave keeping record of video log)
11:40 Finish logging Bw-12. Dave begins stowing equipment
12:20 Move to Bw-12. Set up for log. I take pictures during set-up. Casing for Bw-12 is 14", not 12" as in report
Pictures 2-9: Set-up.
13:00 Start logging Bw-12. Water is very cloudy, especially below about 250 ft. Hard to see anything. About 1 ft oil.
14:30 Finish logging Bw-12. Pull out equipment and pack up. Note: Reference point is 8 ft below ground surface
15 06 Leave and drive to Bw-27. RAPCOM is locked up due to war. Get someone to let us in. Next time, call: Ben ~~Mays~~ Maes
Gary Smith (Environmental) - 929-5533
15:30 Set up to log well. I take pictures 12-14.
15:45 Begin logging well. Don't see any oil on water.
16:30 Finish Bw-27. Move to Cw-150 & set up.
17:10 Begin logging Cw-150. Very little oil.
18 05 Finish logging Cw-150. Were unable to reach total depth because of obstructions in the hole. Pack up gear.

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	2/12/91	Recorded by	

From Page No. March 13, 1991

8:00 Called Walt Short of the SACRAMENTO WATER DEPT.
He said SMUD would be on site about 8:30 to shut off the
Power to the Panel and pump station. City uses ≈ 275 gpd/person

8:45 SMUD arrives at City well 150 at Dowhar and Astoria.
Power disconnected and lines grounded

9:20 Layne Western on site - set up over well head - Mark Lang + Craig Correia
Bailer run down well and line marked every 100 feet.

Obstruction at 168 feet passed dropping bailer down the well - Obstruction
was presumably knocked loose

1st run down - 348.5 feet - didn't bring up air line
2nd run down - 355.5 feet - didn't bring up air line
11:00 3rd run down - 368 feet
- felt the air line at ≈ 183 feet going down
11:20 pulled up an air line ≈ 22 feet of 1/4" galvanized ~~iron~~ ~~or~~ steel pipe
11:30 4th run down 353 feet

Mark Edward Laing
SS # 555-08-0249
Cal DL # N4871497 "Class A"

Craig Allosl Correia
SS # 532-94-2688
Cal DL # C5903862

Capt Slavitch 643-1250

12:30-1:45 5th - 7th run - pulled ≈ 300' of pipe - bailer ended up at ≈ 370 feet

Notes - City uses ≈ 30 to 50 mgd on wet winter days
≥ 200 mgd on Hot summer days
Walt thought average use for the year was 275 gpd/person

2:00 Decon bailer and wireline at McClellan decon area by Universal Engineering
trailer.

3:00 Check in with base environmental personell - Capt Slavitch out - returned a base
pass from one of the Layne personnel no longer on the job.

To Page No.

Witnessed & Understood by me, | Date 3/13/91 | Invented by | Recorded by | Date

From Page No.___

Mar. 18, 1991

11:15 Meet Gary Gardner and Craig Correia of Layne-Western at the Palm Street Gate - drive to EMR Lorraine is at lunch - can't get passes - so decide to drive to wells and inspect. Each well has a water supply available - spigots for rehabilitation - hydrants for cementing.

13:30 Return for passes. While they complete paperwork, I talk to Fran. Ask him to check on use of hydrants, fill him in on progress.

14:00 Go get Gary's and Craig's pictures for I.D.s, then move to Bw-1.

14:15 As they set up, I go phone Rob + arrange for him to be present 3/19-21.

14:30 Calibrate HNU # 1149 (Hazco) to 100 ~~ppb~~ ppm isobutylene. At span pot = 10.0, meter reads 80 ppm.

14:45 Have Safety Meeting, find that Plan doesn't include map to base hospital.

14:55 Drive to base hospital to confirm location - corner of Dudley Blvd + Palm St. I return and describe location to Gary + Craig.

15:10 Begin lowering bailer. I monitor workspace air: 0 ppm Downcasing air: 0 ppm. Continue to bail oil/water from the well. Extend bail only a couple feet into ~~hole~~ water each time to minimize collection of water. Bailer 6" x 10 ft steel bailer I monitor with HNU: 0 ppm On 1st pass into hole, dipped bailer entirely below water surface so water/oil flowed into the top of the bailer. Then partially submerged about 10 times, then completely submerged until 55-gal. drum was filled. Difficult to tell how thick the oil is in the drum, because (apart from thin dark layer) most of the oil is light colored. I drop the sounder down - registers water at 110 ft, but when comes up the lower 3 feet is covered with oil. We decided to return on 3/19 with more drums and continue bailing

To Page No.___

Witnessed & Understood by me,	Date	Invented by	Date
	3/18/91	Recorded by	

From Page No.

16:10 Begin stowing gear for the day.
16:25 leave site

March 19, 1991 Gary Gardner Craig Correia from Layne Western

Well 1
Depth to oil surface ~ 109.7 ft from top of pvc
Depth to water surface ~ 110.2 ft
Thickness of oil ≈ 0.5 ft.

Well 2
Depth to water 109.29 ft from top of pvc

– no oil on probe when it was pulled up.

Well 2
Depth to oil surface 98.87
Depth to water surface 98.60
Thickness of oil ≈ 0.27

Drillers on site 2:00
Bailed oil off well for the rest of the afternoon – bottom of oil still at 110.2'
Used both the bottom of the

4:30 – set up scratcher for Well 1
5:00 Leave site

Wednesday March 20

8:30 Drillers on site – They set up steam cleaning nozzles in their shop.

~~Str~~ Rotary scratching typically takes 20 minutes per 20 foot section of screen.
Well 1 is screened 153 – 353 feet
Total depth measured 361' 8" before scratching – 352' after scratching
⇒ 10 feet of metal chips in bottom of the well.
9:30 Start scratching entire screen in ≈ 200 foot strokes
2:10 Stop scratching note – some passes were made above the screen too

To Page No.

Witnessed & Understood by me, Date 3/19/91 3/20/91
Invented by Date
Recorded by

TITLE Bw-1; Bw-2 Book No.

From Page No.

Photos March 19 - 1991

0-4 Bailing (dipping) oil from surface of water in well Base well 1

4-7 Setting up wire brush ≅ 12" diameter scratcher for Base Well 1

11-12 Steam cleaning cable while scratching slotted screen 153-353

14 Photo of Bailer with water from Well 2 - no oil on water

March 20 1991 Continued

3:10 - pulled scratcher and 3, 20 foot pieces of 2 3/4" drill pipe out of well put them on the rig and went over to decon - set up cones and talked to vehicle owners at well 2

4:00 Setting up at Decon - decoaning on blue tarp.

5:00 leave site

March 21, 1991

8:00 On site - pick up SMEAL pump rig at decon site and move to Base Well 2 set up rig derrick over well. I ran a 2" Clear Teflon bailer down the well and found no oil on top of the water - clear water was in the bailer and no oil was on the outside of the bailer. ~~Therefore~~ The water table is within the first screened interval of well 2 and whatever oil was on the well surface has long since disapated into the formation and moved downgradient. Therefore, I decided not to bail the well to remove oil that wasn't there and go directly to line scratching the well screen.

11:00 Scratcher and steam cleaner in place - start scratching

To Page No.

Witnessed & Understood by me, | Date 3/20/91 3/21/91 | Invented by | Date | Recorded by

Project No.____
TITLE Bw-2; Bw-12 Book No.____

From Page No.__ March 21, 1991 Continued

The scratcher would not fall below 295½ feet below grade (cement pad)
This well was video logged on Feb. 12 (p 11-12) by Dave Locherby.
The video picture went dark at 286-287 feet and the camera stopped at 288 feet.
Reported original well casing depth is 288 feet.

11-1:30 scratched ~90' → 295'

130-2:30 Equipment breakdown

2:30 -4:00 Scratched again - total of 4 hours (240 min)

Bottom at 293½ feet Therefore 2 feet of metal chips in bottom of well
Scratcher started sliding more easilly around 3:01 - Is the scratcher getting worn or is the well encrustation cleaning up more easilly with Line scratching on well 2.

Set up ~~barricad~~ cones and flagging to assure access to Bose Well 12 tomorrow.

4-5:00 Pullout scratcher assembly, load pump rig leave site.

Friday, March 22, 1991

10.00. Arrive onsite. Gary and Craig have deconned rig & gear, and are currently set up over Bw-12 and bailing oil.
I calibrate HNU #1179 (HAZCO) and monitor breathing space above hole. 0 ppm. Air downhole also: 0 ppm

After bailing about 1½ ~~bar~~ drums of oil/water from the hole, drillers believe they have all the oil from the hole. Set up to "scratch" the casing, and find that the casing diameter is actually 13 5/8" in diameter — not 12 inches as reported in LSCE, 1984. Must fabricate a new tool.

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	3/21/91		
	3/22/91	Recorded by	

From Page No.

13:30 - Go to decon rig and bailer.
15:00 - Leave site for the day. Layne will fabricate new scratching tool over weekend. Area around BW-12 is barricaded so that Layne can return and set up on Monday morning.

March 25, 1991

Drillers setting up and installing new 13 ½" scratcher - scratcher fits well but gets stuck at 141 feet. Drillers will try to put down the 12" scratcher and see if it ~~go~~ will go below 141 feet.

The 12" scratcher also got stuck - they pulled it up and some brownish pea gravel ≈ ¼" dia was on top of the brushes. Therefore there may be a hole in the casing which could be letting gravel pack gravel into the casing

The Drillers pulled out and installed the 12" scratcher with 60 feet of 2¾" drill rod above it - the scratcher then went below ~~the~~ 141 feet. - The well may have telescoped ~~down~~ from ≈13 ½ inches to 12 inches at 141 feet. Perforations ~~start~~ around 157 feet. The well is ≈374 feet deep

The upper-most casing near the well head is slightly egg shaped. Herb DeWet noted that the well was ~~crook~~ crooked. When Herb pulled the pump ~~the~~ He had to recenter the pump column each time he removed a 10 foot segment of pump column. Gary Gardner is also finding that the ~~pu~~ well is crooked during scratching it.

Well depth 380.6 feet before scratching

12 inch scratcher feels like it is in a 12 inch well according to Gary Gardner. Well is being scratched from 155 feet below top of casing (around 10 feet below ground) 225 feet down to 380 feet. Gary is scratching in 225 foot strokes for > 4 hours. Therefore they won't finish scratching until tomorrow morning. The hole where gravel came in is above ~~wh~~ the screen where they are scratching

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	3/22/91		
	3/25/91	Recorded by	

TITLE Bw-12; Bw-27 Book No.______

From Page No.__ March 25, 1991 continued

le The 12 inch scratcher doesn't feel to have as much drag as on Base Wells 1 and 2
Tom [illegible] of Layne reviewed the video tape in Woodland

The video shows a taper around 135 feet, but couldn't tell how much the diameter decreased

2:00 Guy will scratch the well for the afternoon with the 12" scratcher and try moving back and forth across the hole some while scratching.

4:00 Steam cleaner broke down - Leave for Layne yard in Woodland to get another one

Tuesday March 26, 1991

8:1 Scratching well 12 - 5 1/2 feet of metal at the bottom of the well at the start of the day.

7 1/2 feet of metal fill at the end of scratching

1- pulling tools out of the hole + decoming ⇒ total depth after scratching was 373 ft

Personnel working ~~at w~~ near informed drillers will be coming and put cones set up by base well 27 a 6" well.

Wednesday, Mar. 27, 1991

11:30 I drop by well Bw-27. Layne is "scratching" well. Say they had to trim scratcher slightly at a depth of 179 feet, due to narrowing of casing.
2:00 Begin to pull out of the well. Reached a total depth of 252 feet before scratcher couldn't move further — too tight. So, lowest 9-10 feet not "scratched".
Pictures 24 & 25 - pulling out scratcher from Bw-27.
We discuss procedures to follow next few days
Picture # 1 - the scratcher.
3.15 They go to decon, I return to office

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	3/25/91 3/26/91 3/27/91	Recorded by	

Thursday, Mar 28, 1991

(Layne performs video log of Bw-1, 2 and 12.
Sets up to perforate Cw-150)

Friday, Mar. 29, 1991

8:00. Layne crew arrives at Cw-150. Finishes setting up for perforation. Will use a hydraulic mills knife - 6@ 4x6 inch slots (slotted at 90-degree intervals around the casing) - one set of slots per foot.

On Cw-150, begin perfs at 140 ft. Static water level is about 98½ feet. Will perf up to depth of 85 ft

Monday, April 1, 1991

8:00 Arrive at Cw-150 Halliburton crew present:
Don Pierce : 546-90-7187
William Lacey : 571-04-7238 (Lorraine prepares passes)
Richard Kunce : 565-58-8765
Richard Ballard : 547-62-5090
Dom Pooke : 552-78-8265

We wait for Layne to arrive. I call Walt Short, who will send someone to open gate and check into progress on having attachment made so Halliburton can draw water from City lines
I go base to start passes - but Lorraine out
10 00 Layne arrives, begins setting up. Drop tremmie pipe to about 367 feet (3 feet off fill depth of 370 feet).
Halliburton discovers that packer doesn't fit hole. Assumed that 14" casing with 1/4" walls was really 13½" casing
More phone calls, decide can fabricate new one by Wed

Witnessed & Understood by me,	Date	Invented by	Date
	3/28/91 3/29/91 4/1/91	Recorded by	

From Page No.

11:00 Able to go get passes for Halliburton crew. Afterwards, we visit the wells, measure diameters, check access.

11:30 Layne moves and sets up to perforate Bw-1.
13:45 They don't have enough pipe to get to depths needed to perf the well. Decide to install the pipe they have, then go for more.
Agree to perforate the following intervals in Bw-1:
95 - 153 ft
179 - 232 ft
300 - 340 ft
This allows about 5 feet on either side of existing slots, and brings the perfs about 16 feet above the static water level of 111 feet.
Pictures 4 & 5 - the mills knife - hydraulic perforator
" 6 & 7 - the Pitman Hydra-Lift - set up over Bw-1.
2:00 I leave site & return to the office

April 2, 1991

Gary and Robert (Layne) perforate Bw-1
Picture 8-11 → Gary + Robert in action

I instruct Gary & Robert to perforate Bw-2 at the following intervals: 115 - 135 ft
163 - 175 ft
202 - 275 ft
(They don't have time to perforate Bw-2)
April 3, 1991

Gary and Robert finish perfing Bw-1. Took longer than expected because they had trouble communicating. (Gary inside building, Robert outside operating crane)
Eric videos Bw-2?

To Page No.

Witnessed & Understood by me, Date 4/1/91 4/2/91 4/3/91 Invented by Date Recorded by

TLE Cw-150 Project No.____ Book No.____

From Page No.__

April 4

8:30 Arrive at CW-150. Halliburton and Layne are onsite, setting up. Tremmie pipe is in the well, set at 360 feet.

Decide to pump 23.5 ft^3 - estimate 2.35 ft^3 per foot of casing (14" diameter casing - 1.07 ft^3/ft.
borehole diameter = 28", or 4.28 ft^3
annulus volume = 4.28 ft^3 - 1.07 ft^3 = 3.21 ft^3
assume 40% porosity = 1.28 ft^3/ft
thus casing + annulus:
1.07 + 1.28 = 2.35 ft^3)

Will pump 23.5 ft^3 of cement to fill lower 10 ft. of well.
Well depth = 372 ft
Previously logged depth at 370 ft after removing debris.
Will pump 23.5 ft^3, should bring cement level to 360-362 ~~360~~ ft if completely fills gravel pack. However, will assume that none goes into gravel pack. Assume fills casing only, rises to 22 ft, to 350-foot depth. Will set packer conservatively at 330 foot-depth.

Cement mix: 50/50 Pozmix
2% bentonite gel
3% $CaCl_2$

9:00 Safety meeting + discuss approach
(Capt. Slavich arrives + departs during meeting)

9:30 Rob arrives - prepare to pump. Will pump 3 bbl water first to get circulation going.
Cement density adjusted to 14 lbs/gal.
Inject at rate of 1 bbl/min.
(I take pictures 12-18 of setup)

Note: 1 ~~cu~~ ft^3 = 7.48 gal = 0.18 barrel
So 2.35 ft^3 = 0.42 barrel

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	4/4/91	Recorded by	

From Page No. April 4

$23.5\ ft^3 = \frac{1\ ft^3}{0.18\ barrel} = \frac{23.5\ ft^3}{x\ barrel}$

barrels = 4.23 barrels

mixed 2½ barrels water with 18½ sacks cement for first lift. Dom Poore says this calculates to 23.5 ft^3.

9:50 Finish pumping cement. Remove 3 sections of tremmie pipe

(Note: Tremmie pipe diameter is 2 7/8"
Joints are "mixed 20's" - ie, 20 to 25-foot lengths)

Now flush cleanup water downhole - water mixed with cement residues inside mixer & lines, etc.

Pos mix is 50% Posaline at 74 lbs/ft^3 (sack)
50% Permanente Class 6 cement 94 lbs/ft^3/sack
= 84 lbs/sac

Water requirement varies with weight of slurry. In this case 14.1 lbs/gallon

5.75 gallons per sac. at 14.1 lbs/gallon mix

We used 9.3 sacs Cement } = 874 lbs
9.3 sacs Posalite } 688 lbs
+ 2% gell = bentonite } by weight 31 lbs
+3% $CaCl_2$ } 47 lbs
105 gallons water * 8.33 lbs/gallon = 875 lbs | 1640 lbs solids = 2515 lbs total

23.6 cubic ft mixed at 14.1 lbs/gallon

Note bentonite is 60 lbs / ft^3
$CaCl_2$ 56.4 lbs / ft^3

15 barrels water ~~are~~ run through system to clean & flush
Expect some losses in volume of cement injected, as adhering to pipe & equipment
So, assume 17-18 ft^3 in hole.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	4/4/91	Recorded by	

yeild facto- in this case is 1.26 meaning volume of mixed posmix cement per 1 ft^3 sack of cement when the appropriate amount of water is added for a 14.1 lbs/gallon slurry (= 105.5 lbs/ft^3). $CaCl_2$ and bentonite also added.

2% $CaCl_2$ will reduce setup time to around 4 hours based on Halliburtons experience.
No more than 3% $CaCl_2$ should be added. If one went over 6% $CaCl_2$ it would act as a retordant ~~fed~~ lengthening setup time.

Fluid loss addatives would probably clog the ≈0.060 to 0.080 inch louvres on modern water well screens. ~~The addat~~ Celephane celulose material is often used as a fluid loss addative.

The halliburton cement mixer has a density meter that reads in lbs/gallon. They mix cement posulite + bentonite and ~~calcium chloride~~ ~~and add~~ water is put in solids added until the desired density is achieved before pumping. When mixing a small batch such as the 23.6 ft^3 we started with, around 20% of the mixture will be lost in the mixer plumbing and 360 feet of tremmie pipe. Therefore the amount which actually got placed downhole is probably around 18 ft^3

The tremie pipe was raised 3 joints ≈ ~~63~~ 75 feet by Layne Western and then 15 - 42 gallon barrels was washed through the mixer and tremie before running the packer down the hole.

Note - Having trouble running the packer down the hole. using a come-along winch to run it down.
Packer is 14" —
11:15 Packer stuck at 3½ joints ≈ 88 ft
Add water in casing to surface for added weight, but still doesnt move. Decide to pull it out and grind the circumference of the packer down. However, when the packer reaches ground surface we see gravel on top. Assume that we've torn casing.

Decide to forgo packer on this well – too much chance of losing it in the hole. Instead will seal in lifts, as before – add water in top of hole with 4-inch hose (not tremmie – smaller diameter, more frictional loss). Turn water off after 5 minutes and sound – ∇ at about 60 ft – ~~80~~ – getting some head in hole. Turn back on, rises to w/in 3 feet of ground surface and stabilizes.

13:45 Cut water off.

14:30 Tag cement at 359 ft. Decide to go ahead an pour remaining cement into hole. 359 ft. means last batch worked as expected. Will pump 7 barrels ~~27 ft³~~ (39.3 ft³) into hole (This should raise it 16.6 ft × 0.9 = 15 ft in hole, or to about 344 ft.)
(0.9 is a "loss factor" to account for cement adhering to side of pipe, inside equipment, etc.

If no cement flows to formation, then would use 39.3 ~~27~~/1.07 = 36.7 ~~25~~ ft in casing. So, will pull 3 25-ft joints from hole to avoid possibility of cementing pipe in the hole.
Cement density was 14.5 lb/gal. Pumped into hole at 2 bbl/min. (Added 3½ bbl water to 11 sacks cement)
Circulate 15 bbl water through system to flush, then pump into hole.
Add water to casing until it reaches ground surface.
Maintain head of water to squeeze cement.
Halliburton & Layne clean up & move equipment to Contractors staging area on base.

16:45 Shut off water (maintained head for ~ 2 hrs)
Head to office

NOTE: Actually, no "loss factor" since pumping water through system & pipes in sufficient quantity and pressure to displace the cement

Witnessed & Understood by me, | Date 4/4/91 | Invented by | Date
Recorded by

From Page No.____

April 5, 1991

6:00 Arrive onsite (Layne & Halliburton). Set up and tag cement at 330 ft. So, came up 29 ft in hole.
(If all had gone into gravel pack — 344 ft.
(If all had remained in casing — 322 ft.)
Apparently, did not get perfect squeeze.
May have been due to only applying squeeze for 2 hours
May have been due to slightly higher density - 14.5 lbs/gal - of last batch.

6:15 Hang tremmie at 327 ft and pump new batch:
15.0 ft^3 of 50/50 Poz premixed w/ 2% gel & 3% $CaCl_2$.
16 BBLs mixing H_2O - Displaced w/ 1 BBL H_2O
Pumped @ 2 BBL/min. Density = 14.1 lbs/gal.

6:40 Cement in place. Remove 7 joints of pipe and flush wash water. (use 20 bbls water)

7:15 Pull remainder of pipe from hole

7:25 Start water in hole. 6 ft rise to ground surface

= if all works properly, will rise $15.0 ft^3 / 2.35 ft^3 = 64$ ft. (266 ft.)
if all stays in casing, will rise $150/1.07 = 140$ ft (190 ft)

Note: 50/50 Pozmix is 84 lbs./sack.
1.5 sack = 1 ft^3 cement (#sacks × 1.26 = ft^3 for Theo mix)
1 sack cement is 94 lbs.

For each lift, Halliburton pours sample in cup, and watches for set-up. When set, provides indication that is set in hole. Conservative, because cement in hole is under pressure, which causes it to set up faster.

Todays batch sets up faster than yesterdays (2½ hrs). Due to "drymixing" $CaCl_2$ with batch, rather than mixing to wet batch at jobsite.

To Page No.____

Witnessed & Understood by me, | Date 4/5/91 | Invented by | Date
Recorded by

9:50 Turn off water - sample cement has setup firm
Go into well to tag.

10:15 214.6' Top of cement. Came up too far. Necessary to adjust next batch. Will switch to neat cement 0.75% CFR-3 & 2% bentonite, but. Will add $CaCl_2$ at jobsite. Necessary for Halliburton to return to yard for new mix.

12:00 Bulk truck returns with new mix. Begin preparing to pump into hole. Will use 75 sacks type G cement and 2 sacks $CaCl_2$ (3%). 9 bbls water. 2% bentonite
Density: 15.6 lbs/gal
Injection rate: 2 bbls/min
1.34 ~~1.60~~ = calculation factor for converting bags of cement to ft^3 with this mix
(75 sacks)(1.34) = ~~[illegible]~~ 100.5 ft^3 into hole

Note: calculations off due to incorrect assumptions of cement quantities

ideal: 83 / 2.35 = 35.3 ft of rise.
Raise to 180-foot depth (776)
all remains in casing: 83 / 1.07 = 78 ft rise
Raise to 137-foot depth.

12:25 Finish pumping cement. Pull 4 joints out and flush cement/water washup water downhole (~17 bbls)

12:55 Pull remaining pipe from hole and add water
13:00 Casing full of water. Allow cement to set
14:50 Cement sample is hard. Tag cement in hole - 140.5 ft
So, has risen up too far in the hole. Discuss problem w/ Fran, who drops by site. Either we aren't applying enough pressure, or cement is setting up too quickly (before we have time to apply head of water).
Decide to eliminate $CaCl_2$ from next batch and cut amount in half (This because we are nearing the water table, the most important zone, will

Witnessed & Understood by me,	Date	Invented by	Date
	4/5/91	Recorded by	

From Page No.

proceed conservatively.

15:30 Finish pumping batch into hole. Gauge said 7 bbls cement:
7 bbl = 294 gal = 39.3 ft^3
Density = 15.4 lbs/gal

If fills gravel pack, will rise: 17 ft to 123 ft depth.
If only fills casing, will rise: 37 ft to 103-ft depth.

Pulled tremmie pipe back to 75-ft depth and circulate wash water, then pull tremmie pipe from hole.

16:00: Attempt to tag grout w/ sounder, but can't "feel" by total depth of 149 ft (buoyancy probably keeps line from hanging straight). Notice that DTW is only 26 feet. Add water to bring to surface, then must continue to add to maintain level.

Monday, ~~May~~ April 8, 1991

8:00 Halliburton + Layne present since 7:00 a.m.
Logged cement at 108.5 ft

Goal cement to 90 ft (18.5 ft)
43.5 ft^3 at 2.35 ft^3/ft.

Well Cw-150 is perforated to depth of 85 ft. Water level is about 98 ft. By cementing to 90 feet, will allow water to drain out of casing. Am concerned that insufficient amount of cement going to gravel pack. Will set packer at 70 feet and apply squeeze.

Cement composition = Class G Portland cement with 0.0075 CFR-3 and 3% CaCl$_2$ and 2% bentonite

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	4/5/91		
	4/8/91	Recorded by	

From Page No.

Mixing 37½ sacks (about 7½ barrels)
Density = 15.6 lbs/gal
9:30 Begin pumping into hole at 2 bbs/min.
Potential range of final sets:
68 ft (none goes to gravel pack)
90 ft (all goes to gravel pack)
Leave 2 joints in hole for wash up

While pumping wash up water down hole, water fills casing and overflows onto the ground. Likely that cement in hole prior to squeezing has risen above tops of perfs, leaving no place for water to go. Decide to direct remaining wash water (100-200 gal) onto field next to well, since is not contaminated and shouldn't leave too much mess.
Attempt to force packer downhole. Necessary to use come along to force down. During process, some water flows out the top of the pipe.
Packer is set at depth of about 50 feet. Connected to water, which is pumped under pressure.
Sets boom of crane onto top rod to keep from coming up under pressure. Applying 50 psi into hole, then easing off as pipe rises slowly - constantly applying pressure to squeeze cement as it sets up. After 3 bbls injected, water begins breaking ground surface at top of casing. So, about $(3\ bbls)\left(\frac{42\ gal}{bbl}\right)\left(\frac{1\ cf^3}{7.48\ gal}\right) = 16.48\ ft^3$

displaced. $\left(16.48\ ft^3\right)\left(\frac{1\ ft\ casing}{1.07\ ft^3}\right) \approx 16$ feet of casing reclaimed from cement, displaced into formation.
10:30 As water breaks surface, stop applying pressure. Pull tool from hole, see that piece of ~~robbing~~ rubber torn off of packer. Unsure if pressure did it, or if it tore off from something sharp in casing.
Standby, allow it to set.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	4/8/91	Recorded by	

From Page No.

12:35 Go in to Tag CW-150. Cement is at 77.2 ft. Since conductor casing extends to 74 ft, decide not to perforate well further. Instead, rent pump to remove water from casing — water extends to surface in casing — did not drain, is wash water and injected city water. Will pump water onto adjacent field as install final lift of cement.

Final mix is 50/50 Pozmix as before (2% bentonite, 3% CaCl — left over from other day).

13:20 Begin pumping into hole. Bring all the way to surface, then allow it to settle as hung out rods. However, calculate should take 14.7 bbls, and has only taken 7. So, pump out gray water and continue to inject cement.

13:40 Cement to w/in 4.5 ft. of surface. Break down, clean-up. Layne goes to decon.
Tom P. and I go to scout access and needs at BW-27, our next well.
(we talk to building supervisor, make arrangements to come in back gate & set up on 4/9)

14:30 Layne goes to decon, Halliburton moves equipment to staging area, I return to office

Note: Comparing field notes on cement volumes with ~~on~~ ticket given me by Halliburton, I note they delivered more cement than we thought we were pumping. I ask Halliburton, who tells me that quantities on ticket are accurate, based on count of actual sacks at plant. Difficult to measure small quantities precisely in field w/ gauges on rig. So —
Notes: Used 229 ft^3 Pozmix = 182 sacks
Ticket: ~~Used~~ 352.8 ft^3 Pozmix = 280 sacks
Notes: Used 138 ft^3 Class G = 120 sacks
Ticket Used 172.5 ft^3 Class G = 150 sacks
Multiply volumes above; (Pozmix) X (1.54) and (Class G) x (1.15)

To Page No.

Witnessed & Understood by me, | Date 4/8/91 | Invented by | Date
Recorded by

From Page No.

Tuesday, April 9, 1991

7:00 Halliburton and Layne arrive and set up at BW-27. I ask Layne to perforate lowest 15 feet of BW-27, since video survey was dark and cloudy in this zone (implying that either no slots, or slots are clogged. I meet with Richard of Halliburton, and discuss cements, additives, alternative tools to improve on operation at CW-150. Gary informs me that the perforator won't fit the casing — too large. He goes to phone & locate another. I decide to trust well log and attempt to inject cement into lower zone.

9:30 Fire department arrives and turns on hydrant.

Hole volumes:
Assume 6" casing in 16" borehole
Assume 40% porosity in gravel pack.

Then 0.68 ft^3 per ft of casing including borehole
0.20 ft^3 per ft of casing w/out borehole

Minimum that can inject is 3 bbls cement, or 17 ft^3. If lower 20 ft is perfed (240-260 ft - as per log) - and if fill in bottom of casing is easily displaced fluff, then (20 ft)(0.68 ft) uses 13.6 ft^3. Assuming remainder contained in casing, (3.4 ft^3)/(0.2) = 17 ft casing. Thus, cement will rise at least 37 feet. Will set packer immediately below next to bottom perfs at 223 feet.

I sound well, discover that water level is at 92 ft. Thus, Layne video is 6 feet off. Necessary to adjust depth of slots.

Using 50/50 Pozmix cement w/ 2% gel. No $CaCl_2$
14.3 lbs/gal

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	4/9/91	Recorded by	

From Page No.

Range of possible set depths: 175 ft (none in formation)
2236 ft (formation + casing)

10:15 Inject first load of cement. Begin wash up.
(1 take pictures)
10:40 Finish injecting washup water. Pull tremmie pipe & install packer. When last pipe comes up, some cement is on it that appears partially set up already.
Installing packer, run into difficulty at ~25 feet where video log showed separation or encrustation on the joint. Push w/ boom and get past.
At ~175 feet, pipe starts going slow, indicating that the packer has hit the cement. Decide to push down to 200 feet and squeeze from there.
11:10 Inject 2½ bbls water under 60 psi. At that point, when release pressure, the hole develops a vacuum and starts "sucking" water.
11:15 Stop squeezing. Pull packer out of hole to prevent it being cemented in place. Packer comes up clean and undamaged.
11:35 Apply head of water to additionally squeeze cement.
13:30 Tag cement at depth of 251 ft. So, lost most of cement to the formation.
Will inject 3 bbls of 50/50 Pozmix again: 2.90 gal; 3% CaCl. Will inject through packer, and set packer at ~~230~~ 223 ft (perfs are ~~240-260~~ 212-222). Will apply "light" squeeze, then immediately pull packer up out of hole to avoid getting it cemented.

(monitoring workspace air. As at CW-150, no readings above background on HNu)

3 bbls cement = 16.84 ft^3

9 ft of screen & gravel pack takes 6.1 ft^3.
So: need to displace about 13 feet casing, so inject $(13)(0.20) = 2.6\ ft^3 = 20$ gal to bring top of

To Page No.

Witnessed & Understood by me, | Date 4/9/91 | Invented by | Date | Recorded by

From Page No.__

cement to 235 ft.

First, inject 2 bbls water to get circulation. Then, inject 3 bbls cement; then 1/2 bbl water to squeeze

Cement density: 14.1 lbs/gal

Lowers boom onto piping to keep from rising in the hole.

Even injecting at slowest possible rate (~ ½ bbl/min) causes pipe to rise out of the hole. Conclude that lower perfs must be cemented off. Decide to raise packer and set at 200 feet. Now attempt to inject into perf. zone at 212 - 222 (206 - 216?). Again, inject slightly less than ½ bbl water.

15:15 Finish injecting, immediately pull up packer. "Feels" heavy, as if cement has traveled up annulus.

Leave one 25-ft. joint in hole, and flush wash water downhole. Using about 15-20 bbls water for washup.

16:00 Allow to setup overnight. Pull packer, no cement visible. Leave site for day.

Witnessed & Understood by me,	Date	Invented by	Date
	4/9/91	Recorded by	

From Page No.__

Wednesday, April 10, 1991

08:00 I arrive onsite. Layne & Halliburton present, are running in pipe with packer attached to plug cement.
Cement seems to be at 182 ft.
This seems odd, since packer was set at 200 ft when cement was squeezed. Either - (1) Not all cement was squeezed - some was left in pipes and drained out when pipe was pulled, or (2) packer now stuck in casing, not really plugging.
Decide to pull pipe, remove packer, go back in and plug again. Put perforator on.
Confirm cement at 182 ft. Decide to perforate from 153 ft – 174 ft (assume existing perfs from 175–185 ft)

10:50 Finish perfing. Pull out, install packer, set it at 130 feet.
Goal: cement to about 150 ft.
~~[illegible]~~ (29 feet)(0.68 $\frac{ft^3}{ft}$) = 19.7 ft^3 + (3 ft)(0.20)
= 20 ft^3 cement
= 152 gals
= 3.5 barrels

Cement is 50/50 Pozmix w/ 2% gel and 3% $CaCl_2$

Will inject water behind cement.
Displace 20 feet of casing: (20)(0.20 ft^3) = 4 ft^3 = 30 gal
Displace 130 feet tremmie pipe: Inside diameter = 0.21 ft ($2\frac{1}{2}$ in.)
= 4.50 ft^3 = 33.7 gal
total: ~64 gal = 1.5 bbls.

11:50 Begin injecting cement (earlier injected ~3 bbls H_2O)
Pump $3\frac{1}{2}$ bbls cement, then $1\frac{1}{2}$ bbls water.

12:05 Stop pumping. Pull packer up out of hole, then hang one joint back in hole. Inject wash water through pipe.

12:30 Finish injecting water, and allow cement to set.

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	4/10/91	Recorded by	

From Page No.__

15:00 Go in to tag cement. Tag it at depth of 186 ft - Apparently, when tagged this morning - with packer + perforating tool - must have caught on something at 182 ft. Actually, cement must have been deeper than 200 ft (previously, packer set at 200 feet).
Will again set packer at ~~120~~ 125 feet.
Additional 4 feet of hole to cement over this morning's calculations. So (4)(0.68)(7.48) = 20 gal, or ~ ½ bbl.
So inject 4.0 bbls cement
1.5 bbls H_2O to squeeze.

15:45 When injecting water in front of the cement, find that formation "sucking" water at ~ 2 bbl/min. Very permeable. Consider adding additional cement, but finally decide to stick with 4.0 bbls.
(11.1 lbs/gal) Will add 3% $CaCl_2$ to 50/50 Pozmix + 2% gel.
15:55 Finish pumping cement + water. Pull tool and piping from hole. Hang one pipe + pump wash water through it. Allow cement to set overnight.

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	4/10/91	Recorded by	

From Page No.__

Thursday, April 11, 1991

08:00 Arrive onsite. Layne & Halliburton present. Cement tagged at 171 ft. Packer set at 125 ft. Will again cement off this zone, adding Flo-Seal to deal w/ permeable zone.
Goal: cement at 150 ft. (perfs start at 153 ft)
So: $(21 ft)(0.68 ft^3/ft) = 14.3 ft^3 = 107$ gal $= 2\frac{1}{2}$ bbls

plus 3 feet casing = 0.1 bbls

Water: $(25 ft)(0.20 ft^3/ft) = 37.4$ gal
+ pipe 33 gal = $1\frac{1}{2}$ bbls

Will use 4 bbls cement
50/50 Pozmix, 2% gel, 3% $CaCl_2$, 0.25% ~~Flo Seal~~ Flocele

(Note: Flocele is a cellulose film flake, chemically inert, used to control lost circulation zones)

8:40 Pump cement, 14.7 lbs/gal, at ~ 2 bbs/min
4 bbls cement followed by $1\frac{1}{2}$ bbls water.
(Previously pumped 2 bbls water, noticed that formation "sucked" water - indication of high permeability)

8:47 Finish, stop pumping. Pull piping and packer out of the hole. Then, having ~~add~~ one joint downhole and pump washwater into hole. Allow cement to set up.

9:00 Washwater overflows well: not enough capacity in well to hold. Decide to pump washwater into adjacent field

11:20 Begin running in pipe to tag the cement. The sample cup has set up. Tag cement at 140 feet. Decide to begin perforation

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	4/11/91	Recorded by	

From Page No.__

13:15 Finish perfing the well. Hit obstruction 139 feet. So perfed from 109 - 139 feet. Pull out, install packer, run into hole & set packer at ~~100 feet~~ 79 feet.

Amount of cement to pump

Perfed interval: 139 - 109 = (30 ft)(0.68 ft³/ft) = 152.6 gal
= 3.6 bbls

Casing: (146 - 139) = 7 ft
(109 - 100) = 9 ft ; (16 ft)(0.20 ft³/ft) = 23.9 gal
= 0.6 bbls

So: use 4 bbls

Pump water; End up with cement at 105 ft;
Packer at 80 ft. (25 ft)(0.20 ft³/ft) = 37.4 gal
Volume of pipe 33.4 gals
So: need 71 gals or 1.7 bbls water.

13:55 Begin pumping cement (previously pumped 2½ bbls water). Pump 4 bbls cement at 14.7 lbs/gal (50/50 poz, 2% gel, 3% CaCl) and 1½ bbls water. At end, tremmie pipe begins to rise in hole.

14:00 Finish pumping. Pull packer from hole & inject cement wash water. Allow to set up.

15:45 Cement sample setting up. Decide to go in and tag, to see if need to perforate.
Find that cement is at 139 feet, the bottom of the perfs. I.e., lost all cement to formation.
Will try again - set packer at 79 ft. - pump 4 bbls cement with Flocele (50/50 Pozmix, 3% CaCl₂, 2% gel). As before Flocele at ¼ lb per sack.

16:00 Pull out and install packer.

16:20 Begin to inject water downhole to establish circulation. Find that hole will not take any water. Put 50 psi on it and holds it, even after turning pump off.
Decide to perforate from 80 - 109 feet, then cement.
Grayno will perf in AM

17:00 All leave site. I drive to BW-2 and place trolls in zones.

To Page No.____

Witnessed & Understood by me, | Date 4/11/91 | Invented by | Date | Recorded by

Bw-27

Project No.______
Book No.______

Page No.__

Friday, April 12, 1991

08:00 Arrive onsite. Layne & Halliburton present. Layne having difficulty - perforator doesn't seem to work - won't cut into casing. Pull it out - seems in good working order. Go back in to try again.
8 30 Seems to be working. Begin perfing - can't get past 101 feet. Perf from 80 - 101 feet.
9 00 I drive to Bw-2 with Richard, Lonny & Gary. Arrange to have pallets, boxes & dumpsters moved. Try to figure out how will do work.
10:00 Arrive back at Bw-27 Finish perfing, so set packer at depth of 2 feet.
Cement needs.

Perfed casing

$(21\ ft)(0.65\ ft^3/ft) = 14.25\ ft^3 = 106.81\ gal$

Blank casing

$(139 - 101) + (80 - 2) = 38 + 78 = (116\ ft)(0.20\ ft^3/ft)$
$= 23.2\ ft^3$
$= 173.54\ gal$

Total = 280.35 gal
= 6.7 bbls

Will pump 6½ bbls of cement. 50/50 Pozmix - 2% gel
Inject ½ bbl water to squeeze.

10:10 Inject water prior to cementing and find that formation won't take it. Necessary to remove packer. Drop tremmie pipe to 130 ft and pump without packer.

PROBLEM Must have circulation prior to plumbing & pressure

To Page No.___

Witnessed & Understood by me, | Date 4/12/91 | Invented by | Date

From Page No.__

PROBLEM: Cup packer won't hold more than ~50-60 psi before rising up in casing. Necessary to hold down with boom or chains. Halliburton has variety of packers, but are designed for API casing. Our water well casing not standard, won't fit. Must fabricate packer, & cup packer only one that is economically feasible.

* 10:20 Tag cement at 107.5 ft — not 139 ft as thought yesterday. Must not have been set up when we tagged. So - yesterday's cementing was nearly perfect

Change vol of cement needed for final lift:

107 gal
+ (65 128 ft) (84 50 ft)(0.20 ft³/ft) = 16.90 ft³
= 126.4 gal

Total 233.4 gal = 5½ bbls.

For conservatism, will pump 5 bbls. and see where it is.

10 45 Only takes 4 bbls. to fill casing. If none had gone to formation, then (107.5 ft)(0.20 ft³/ft) = 3.8 bbls.
Very little in gravel pack. May not have gravel pack - no information. Drillers log says formation composed of "shaley clay" in zone where perfed.

Note. Hard to read, but log may say borehole is 8-inch diameter. If so, then (0.20 ft³) + (0.06) = (0.26 ft³)
(21 x 0.26) + (84.5 x 0.20) = 3.98 bbls
Exact.

Clean up, rig down.

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	4/12/91	Recorded by	

From Page No.

1400 All set up at Bw-2. Begin to trip into hole with packer. SWL = 109.3 from top of pedestal. Lowest perfs are from 281-295 feet. Will set packer at 260 feet. (I recalibrate + gas HNU and monitor ambient air in building throughout decommissioning).

Cement Calculations:

~~Borehole~~ Casing: 12-inch diameter = 0.79 ft^3/ft
= 5.87 gal/ft

Borehole + casing: 18-inch diameter
Assume 40% = 1.18 ft^3/ft
= 8.83 gal/ft

1st lift: 14 ft screen at 1.18 ft^3/ft
= 16.5 ft^3
= 123.6 gal

Goal: ~~cement~~ cement at 277 ft.
So. 4 feet blank at 0.79 ft^3/ft
= 3.16 ft^3
= 23.6 gal

Total cement: 147.2 gals.
= 3.5 bbls ***See note page 49

Water: tremmie pipe inside diameter = 0.21 ft
So, 0.03 ft^3/ft
(260 ft) at ~~0.03~~ 0.035 ft^3/ft = ~~8.~~ 9.1 ~~86~~ ft^3
= 68.3 gal

Blank casing: 17 ft at 0.79 ft^3/ft
= 13.43 ft^3
100.46 gal

Halliburton lines + piping. They assume ~~2~~ 1 bbls
So: Total water: 5 bbls

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	4/12/91	Recorded by	

From Page No.

(no psi)
15:30 Prepare to pump cement. Circulate 5 bbls H_2O
Note that formation is ~~[illegible]~~ sucking water at
2 bbls/min. Decide to add Flocele = 1/4 lb per
sack of cement
Cement density is 14.55 lbs/gal
Pump cement at about 1½ bbls/min. No pressure
Pump 5 bbls water = occasionally get 10-15 psi, usually 0
15:50 Stop pumping - pull tremmie pipe and packer from ground

* Note: 50/50 Pozmix mixed with Class H Portland
Straight portland is Class G.

Pump cleanup water into hole

16:35 Layne leaves site, Halliburton finishes cleaning up.

Monday, April 15, 1991.

8:00. Arrive at Bw-2. Halliburton present, but not Layne.
Standing by, notes. (only 2 men show up)
9:20 Layne arrives - had rig + personnel delays. Brought a
reel w/ steel cable and weight for tagging cement. Begin
setting up.. 1 monitor with HNu.
Tag cement at 248 ft. Seems too high. Decide to
double check with tape measure & weight. This places
cement at 241 feet.
Can't imagine why cement would be so high ~~[illegible]~~
To go up 50 feet in casing (with no cement into
gravel pack) would require 7 bbls - we only
pumped 3½ bbls.
Decide to go down with perforator, see if can get
past 241. If not, wouldn't have been able to perf
deeper anyway. We'll cement up from 241.
10:00 Rob stops by - we go over ~~[illegible]~~ procedures. Crew
continues to trip into hole w/ perforator.

To Page No.

From Page No.__

11:55 Reach bottom at 250 feet with perforator. Will back up and perforate from 225-245 feet.

12:45 Finish perfing. Trip out, install packer. (Cement on top of perforator) Will set packer at 205 feet.

Goal: bring cement to 220 ft.

So:

Casing + borehole = 240 - 225 = (20 ft)(~~5.89~~ 8.83 gal/ft)
= ~~221 gal~~ 176.6 gal

Casing = (10 ft)(5.87 gal/ft) = 58.7 gal

Total cement = 235.3 gal = 5½ bbls. *** See note page 49

Water: Casing (15 ft)(5.87 gal/ft) = 88.05 gals
Tremmie pipe: (205 ft)(0.26 gal/ft) = 53 gal
Total = 3.4 bbls + 1 bbl (pump)
= 4½ bbs

(I go to office)

14 35 Return as they are pulling pipe from well. Have poured cement & water. Cement density = 14.5 lbs/gal
When squeezed w/ water, pressure at ~25 psi.
After squeeze, formation was "sucking".
Used 50/50 Pozmix, 270 gal, floceld, no $CaCl_2$.
Circulated 5 bbls H_2O prior to cementing, and water "sucked" then, too.

15 05 Finish pulling pipe! Halliburton (Ronny) washes pumps and flushes downhole

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	4/15/91	Recorded by	

From Page No.

Tuesday, April 16, 1991

7:00 Layne & Halliburton arrive. Dog cement with reel at 219 feet - right where it should be.

(Note: Uncertain why cement rose so high yesterday - confirmed rise when saw cement on perforator, and by rise of cement to 219 feet on second lift - could the casing have collapsed near bottom?)

Run in with perforator - cant get past 213 feet, so decide to perf up from 213 to 200 feet. Next interval of existing perfs is from 180-197. Blank from 158-180 feet.

9:00 Finish perfing, pull out. Decide to set packer at 170 feet. Goal: top of cement at 175 feet.

Cement needs

Casing + borehole: 13 ft + 17 ft = (30 ft)(8.83 gal/ft)
= 264.9 gal

casing: 5 + 6 = (11 ft)(5.87 gal/ft)
= 64.6 gal

Total = 329.5 gal
≈ 8 bbls ***
(see note page 49)

Water needs

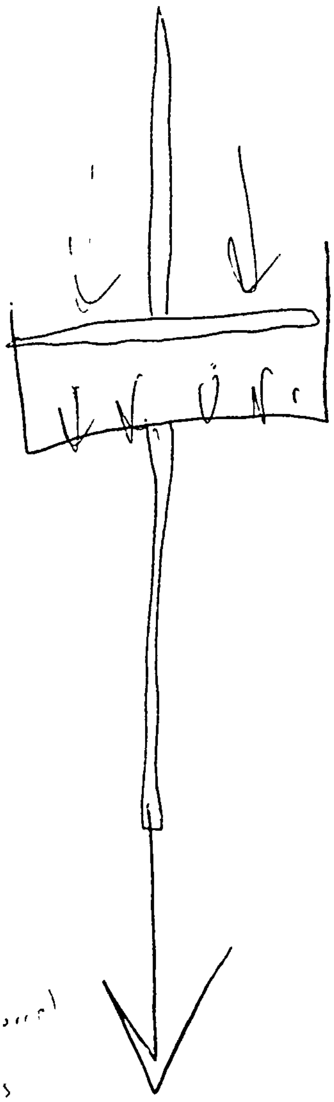
Casing (5 ft)(5.87 gal/ft) = 29.35 gal
tremmie (170 ft)(0.26 gal/ft) = 44.2 gal
Total = 73.55 gal
= 1.75 bbls
+ 1 bbl for rig = 2.75 bbls
= 3 bbls

9.30 Finish pulling out. Go in with packer

To Page No.

Witnessed & Understood by me, | Date 4/16/91 | Invented by | Date

Recorded by

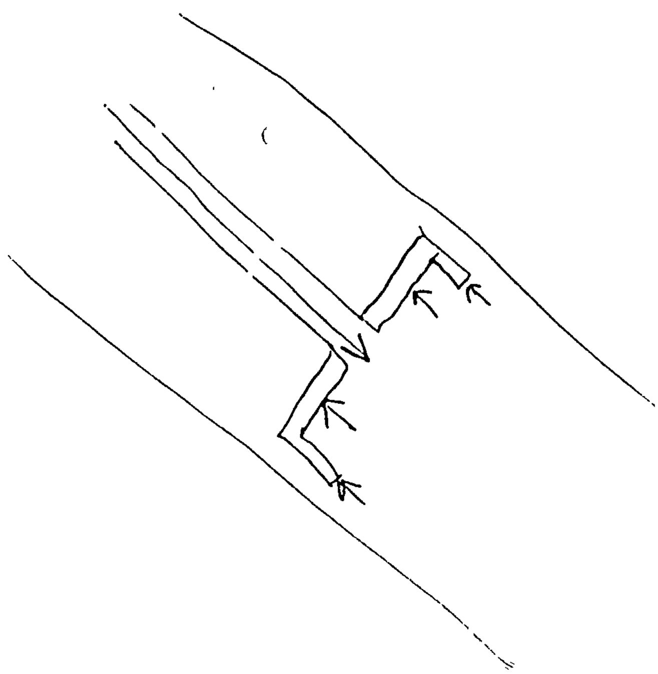


2 - vacuum
8 - 20 psi - 14.1
3 - 50 psi
held

Note:
280 sacks Matrix
yields approx 50 bbls

50 barrels
× 42 gall. / barrel
2100 gallons

$\frac{2100 \text{ gallons}}{7.48 \text{ gallons/ft}} = 280 \text{ ft}^3$



From Page No.__

10:40 Pump Cement → 1st, 3 bbls H_2O to test for circulation – This exerts a "vacuum" on water in pump rig, so decided to add flocele to batch
Pump 8 bbls 50/50 Pozmix – 1/4 lb flocele per sack – 2% gel – 3% $CaCl_2$. 1½ bbls/min at 20 psi. – 14.1 lbs/gal
Follow with 3 bbls H_2O – exerts 50 psi pressure, which pushes packer up (necessary to chain it down – pressure gradually releases on its own).
12:45 Cement in sample has set up. Decide to tag it
Tag it at 177 feet. Good set !!
~~Go in to perforate for next plug.~~ Since cement seems soft, decide to wait and let it set some more – Gary doesn't want to risk perforator.
13:30 Tag at 179. Decide to perforate from 160-170, tag again
Richard, Ronnie & I drive to Industrial Wastewater Treatment Plant. Capt. Slavich has arranged for us to dispose of washwater there. We meet Sgt. Clampitt, make plans
15:00 Return to Bw-2. Find that Layne has been broken down since 14:00 – lost pressure in hydraulic line, can't pull mills knife from casing. They are attempting to repair the motor.

(Note: Fran will be out all next week. Call Alex Johnson as POC)

Halliburton rigs up water line to Layne system to provide hydraulics – seems to work, so proceed w/ perfing.

So. perfed from 160-170 feet; 141-158 feet.
above that is blank from 110-141.
Goal cement at 135
Cement needs: Set packer at 130 feet

borehole + casing: (27 ft)(8.83 gal/ft) = 238.4 gal
casing: (6 ft + 2 ft + 9 ft)(5.87 gal/ft) = 100 gal
Total Vol = 8 bbls ***

(See note page 49) To Page No.____

Witnessed & Understood by me, | Date 4/16/91 | Invented by | Date | Recorded by

Water needs:
Casing: (5 ft)(5.87 gal/ft) = 29.35 gal
tremmie: (130 ft)(0.26 gal/ft) = 33.8
pump & lines: = 1 bbl
Total: 2½ bbls

16:20 I speak to Sgt Parsigan of Fire Dept. - he says we can have 2 sections of 2½ in hose (i.e., 100 ft). Stop by Station #1 & speak to Capt Freeze.

16:30 Begin pumping cement - slowly, since packer trying to rise. At ½ bbl/min and 25 psi, packer rose in hole and bent a tremmie pipe. Decide to slow rate, & continue pumping. ~~limit water & squeeze to only 1 bbl, to avoid further damage~~ go ahead and attempt to inject all of water - at 2¼ bbls, developed 100 psi, and stopped.

17:30 begin pulling out & cleaning up. Packer comes up covered with cement

[Note: avoid use of flocele in future, except in extreme situations]

18:15 I leave for day. Crew keeps cleaning up

Witnessed & Understood by me,	Date	Invented by	Date
	4/16/91	Recorded by	

From Page No.— Wednesday, ~~March~~ April 17, 1991

8:30 Arrive onsite. Top of cement has been tagged at 133 feet (Goal was 135 feet).

Perforator broken down - broken O-Ring - can't hold pressure. Layne heads back to Woodland for new O-rings.

We standby - Rob arrives and we discuss procedures; go by fire dept and pick up 3-lengths of 2½-inch hose.

11:00 Perforator fixed. Layne begins perfing.

Cement needs

Goal: cement to 100 ft.

Casing + Borehole:
(130-100)(8.83 gal/ft) = 264.9 gal

Casing:
(3)(5.87 gal/ft) = 17.61

Total = 282.5 gal
= 6.73 bbs
= 7 bbls cement (*** See note page 49)
(50/50 Pozmix + 2% Gel + 3% $CaCl_2$)

Water needs

Set packer at 90 feet:

Casing + borehole = (10 ft)(8.83 gal/ft) = 88.3 gal
Casing = (10 ft)(5.87 gal/ft) = 58.7 gal
tremmie: (90 ft)(0.26 gal/ft) = 23.4 gal
plus 1 bbl for truck:

Total = 5 bbls H_2O

Witnessed & Understood by me, | Date 4/17/91 | Invented by | Date
Recorded by

Tag water level after squeezing cement.

11:45 Perforator went to 130 feet BGS - start perforating
3:00 Finish perforating, from 112-130 feet. Pull out, set packer.
(14.1 lbs/gal)
3:25 Begin circulating water & injecting cement. 7 bbls cement & 5 bbls H_2O. Upon injecting water, developed 25 psi. Gary had improved the draining of the tremmie - everything went smoothly.
13:50 Finish. Pull packer.

	water level			
	93'	After 7 bbls cement plus 5 bbl water	= 12 on counter	
	63'	after [illegible]	22 on counter	
2:13	53'	15	27	
2:18	81'	21	33	- Finish cleaning cement pump
2:33	90	"	"	
2:45	92	"	"	
3:30	93'			

Call Sgt Clampitt 643-2581 or 2307 - left message at 3:30 - already gone for the day

We have to check in tomorrow morning with Sgt Clampitt at the sewage treatment plant

Need to sign in when we arrive

[illegible] water into the open tank on the cement pumper.
- Ash Richard Dennis - pump truck Bill - [illegible]
- Gary - [illegible] helper Robert.
- Tom Pearson

[illegible] need at least 700 [illegible] 58 [illegible]

= 785 [illegible]

Witnessed & Understood by me, | Date 4/17/91 | Invented by | Date
Recorded by

Assume 22" bore hole and 12" well

22" bore hole $= \left(\frac{11}{12} ft\right)^2 \times \pi = 2.64\ ft^3/ft$

12" well $= \left(\frac{6}{12} ft\right)^2 \times \pi = 0.785\ ft^3/ft$

Annulus 22" to 12" = $1.855\ ft^3/ft$

Assume 40 % porosity $0.4 \times 1.855\ ft^3/ft = 0.74\ ft^3/ft$

Target volume to fill is anular porosity plus 12" well

$= 0.74 + 0.785 = 1.53\ ft^3/ft$

$= 1.53\ ft^3/ft \times 7.48\ gallons/ft^3$

$= 11.4\ gallons/ft$

First lift is 15 feet $= 15\ feet \times 11.4\ \frac{gallons}{ft} = 171\ gallons$

$171\ gallons \div 42\ \frac{gallons}{barrel} = 4.07$ barrels.

Tremmie pipe is 0.26 gallons / ft × 369 ft = 95 gallons =
2" pipe

381 ft including above ground = 99 gallons ≈ 2.35 barrels in pipe to ground surface

Halliburton truck holds 1 barrel cement

From Page No.

16:10 Begin stowing gear for the day.
16:25 leave site

March 19, 1991 Gary Gardner Craig Correia (Layne Western)

Well 1
Depth to oil surface ~ 109.7 ft from top of [illegible]
Depth to water surface ~ 110.2 ft
Thickness of oil ≈ 0.5 ft.

Well 2
Depth to water 109.24 ft from top of [illegible]

- no oil on probe when it was pulled up.

Well 2
Depth to oil surface: 98.87
Depth to water surface. 98.60
Thickness of oil ≈ 0.27

Drillers on site 2:00
Bailed oil off well for the rest of the afternoon - bottom of oil still at 110.2'
[illegible] the bottom of the
4:30 - set up scratcher for Well 1
5:00 Leave site

Wednesday March 20

8:30 Drillers on site - They set up steam cleaning nozzles in their shop.

Str Rotary scratching typically takes 20 minutes per 20 foot section of screen.
Well 1 is screened 153-353 feet
Total depth measured 361'8" before scratching - 352' after scratching
⇒ 10 feet of metal chips in bottom of the well.
9:30 Start scratching entire screen in ≈200 foot strokes
2:10 Stop scratching note - some passes were made above the screen top

To Page No.

Witnessed & Understood by me, | Date 3/19/91 3/20/91 | Invented by | Date
Recorded by

TITLE Bw-2; Bw-12 Project No.______ Book No.______

From Page No.__

well

** Note: Quantity on ticket says 262 sacks. ~~Estimate in field was (249.15 ft³)(1.26 yield) = 198 sacks. Multiply quantities at Bw-2 by factor of 262/198 = 1.32 to arrive at correct quantities~~

Estimate in field was 198 sacks for entire well.
Used 57 sacks in casing, top of well.
Used 205 sacks in remainder of well.
205 sacks ≈ 258.3 ft³ – rest of well
Notes said used 179.65 ft³ in rest of well.
Multiply volumes in notes by 258.3/179.65 = 1.44

Well 12 Initial depth to water 99.7 ft below casing
note casing ≈ 10 feet below parking lot

Initial well depth 376 feet C
Note measured 373 feet after scratching

Set tremmie pipe at 369 feet
Pump 4.2 barrels of matrix - ultra fine cement.

matrix cement yeild 1.97 ft³/ft
density 12.77 lbs/ft
water requir. 11.3 gallons/sac
cement is baby poop yellow.

Matrix
2% $CaCl_2$
0.75% CFR-3

To Page No.______

Witnessed & Understood by me,	Date	Invented by	Date
	4/18/91	Recorded by	

From Page No.

?:35 pumped 4.2 barrels pump

Note injected water - vacume 2 bbls/min no pressure developed ≈ 2?

?:44-46 pumping 2 bbl/min - 0 psi pressure ≈ 4.2

?:48 inject $1\frac{1}{2}$ barrels water 7

~~1/2~~ ≈ 1 barrel of water flushes the Halliburton truck
$\frac{1}{2}$ barrel ≈ 21 gallons flushes $\frac{21 \text{ gallons}}{0.26 \text{ gallons/ft}} = 80$ feet of pipe

⇒ $1\frac{1}{2}$ barrels ~~will for~~ water will force the cement 80 feet down the tremmie or ≈ 70 feet below ground - cement will drain the last 300 feet (300 ft × 0.26 gallons/ft = 77 gallons ≈ 1.8 barrels to drain ≈ 2.4 barrels already pumped in.

?:50 pull 4 joints of 25' tremmie pipe up

2:58 ~~3:00~~ Wash out truck through tremmie pipe - tremie pipe held up ~~thr~~ by the crane.
Also pumping water through 3 ~~hoses~~ hoses running ~~through~~ from Halliburton Truck.

3:03 Washed through ≈ 10 barrels ~~cement~~ 17

3:10 washed through ≈ 10 more barrels ≈7
Now the entire out put of the $2\frac{1}{2}$ or 3" dia fire hose is running down the well - 100 feet of hose to the truck and ≈ 40' of 3" hose. Fire hydrant runs at ≈ 60 psi

3:30 Shut off water - water only come up about 6 feet or ≈ 3 psi which won't help much

345 leave site.

Witnessed & Understood by me,	Date	Invented by	Date
	4/18/91	Recorded by	

Friday, April 19, 1991

8:00 Arrive onsite. Layne & Halliburton present
Have tagged cement at 364 feet.
Original well depth was 376 feet. So, came up
12 feet in hole – appears to have worked.
Crew has already pumped 13½ barrels of (12.7 lbs/gal)
Matrix Cement w/ 2% gel. Set tremmie at 363 feet (1 foot off)
This should raise level to: 314 ft.
(rise of 50 feet)

Wash up equipment, wait for cement to set

12:10 Sample has gelled. Decide to pull pipe out of the hole,
go in and tag with weight.
Tag it at 313 ft. – another flawless lift
Decide to pump another 13½ barrels.
(12.7 lbs/gal)

Monday, April 22, 1991

8:30 Tagged at 268 feet – so, came up 45
feet.
Decide to pour another 13½ bbls cement. If
comes up 50 feet, will tag at 218 feet.

Call Lorraine (643-3672) to arrange pass for
Mark Lang 555-08-0249

Cement density: 12.8 lbs/gal (goal: 12.77 lbs/gal)
Injecting about 2 bbls/min – water prior to cementing
Getting about 60 psi pressure (1st time developed
pressure on BW-12)
Pressure continues as pump cement
After finishing, note that pressure stays high. [illegible]
gauge faulty, developed no pressure.
Pull 4 sections of pipe out of hole for washup.

Witnessed & Understood by me,	Date	Invented by	Date
	4/19/91	Recorded by	

From Page No.

9:30 Finish washup. ~~Pull pipe in ?~~ Add head of water, but still unable to bring it to ground surface (i.e., although have sealed off about half the hole, still have permeable zones that are taking the water).

13:00 Tag cement at 250 ft. So, only came up 18 feet. Previously had been able to put head of 180 nearly to ground surface. Cut off water at ~ 10:30.
Mix and pump another 13½ bbls of mortar.
Density: 12.8 lbs/gal.
This time, will not put head on it.
Goal - Tag at 200 ft
Possible range: 150 ft to 250 ft.

13:45 Finish wash-up

14:10 Close down for day to let cement set up

Tuesday, April 23, 1991

Tag cement at 216 ft (12.8 lbs/gal)
Pump in another 13½ bbls cement (8:00 a.m.) - no head
Goal - Top of cement at 166 ft (12:00)

12:30 Tag top of cement at 188.2 ft
Decide to perf from 138-90 feet, then pump another 13½ bbls (Perfed from 138-85 feet)
Do this, clean up

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	4/19/91	Recorded by	

From Page No.__

Wednesday, April 24, 1991

08:00 Layne & Halliburton have tagged top of cement at 135 feet. So, previous plug came up 53 feet — ~~Dec~~ Have used up all the Metro Cement. Decide to pump 10 bbls of 50/50 Pozmix w/ 3% $CaCl_2$. Put on head of water as quickly as possible.

Volume of 14-in casing: $1.07\ ft^3 = 8.0\ gal/ft$

Casing + 22-in borehole: $1.7\ ft^3/ft = 12.7\ gal/ft$

So, 10 bbls should rise about 33 feet, and top of cement goal is ~ 100 ft, or water table. This will allow drainage (perfed up to 90 feet)

11:30 Tag cement at 108 ft. Water level is at 90 feet, so not draining very quickly. Decide to pump cement down on top of the water in an attempt to force it into the gravel pack or formation.

Cement needs: $108 - 85 = (23\ ft)(12.7\ gal/ft) = 292$ gals
plus $(85\ ft)(8\ gal/ft) = 680$ gals
total = 972 gals
= 23 bbls

12:00 I call treatment plant to inform of our later arrival. Pump cement, but when get up to 38 feet, run out of cement.
Pumped 196 sacks - 44 bbls 14.1 lbs/gal
Send bulk truck back to yard for more. Go to treatment plant to dispose wash up water.

13:15 Treatment plant people stop Halliburton from dumping water. Say their previous sample had set up
We try but can't reach Sgt. Clampitt.
In desperation we drive to lot next to CW-150 & dispose
Will come back later w/ backhoe, scrape up, carry to

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	4/24/91	Recorded by	

From Page No.

dump.

14:30 Return to Bw-12. load up pipe, prepare to move & set packer in Bw-1. In morning, will top off in Bw-12, then move to Bw-1 and pump 1st plug.

Bw-1 cement needs:

Will set packer at 341 feet. Perfs from 345 - 356.

Potential of 10 feet of slough in the bottom of the casing.

12 in casing: 0.785 ft³/ft = 5.87 gal/ft

18 in borehole: 1.18 ft³ = 8.81 gal/ft

So

11 ft casing + borehole - 96.9 gal

4 ft casing only: 23.5 gal

Total: 2.8 bbls

Pump 3 bbls cement

tremmie: (0.26 gal/ft)(341) = 88.7 gal

+ casing : 11 gal

Total = 2.4 bbls

+ 1 for pipes at surface

3.5 bbls water

16:00 While running in packer, becomes stuck in hole at depth of 221 feet. Can't pull out

To Page No.

Witnessed & Understood by me, | Date 4/24/91 | Invented by | Date

Recorded by

Project No.______

TITLE______ Bw-1 ______ Book No.______

From Page No.__

Thursday, April 25, 1991

07:00 Layne brings out 50-ton crane - pulls on packer while Halliburton injects water below. But still won't budge

8:30 Need to resolve 2 problems

(1.) How to cut packer

(2) Where to dispose of cement

9:10 Get visit from a Sgt from Civil Engr. He was called by Base Safety regarding front tires of crane being off the ground (from pulling packer). I ask Layne to release pressure & set truck down.

9:35 I talk to Sgt. Clampitt - he says he has no alternative - cannot let us dispose water.

I request Richard to find out cost of vacuum truck. Can we have Halliburton hire truck & pass cost onto us ?

Richard also checking costs of using Halliburton to cut off packer from piping.

Meanwhile, Layne crew continues to try to free packer.

Halliburton costs to date:

CW 150 = 8586

BW 27 = 4942.

BW 1 = 8381.91

BW 12 = 18,500 (est)

~~4900~~ 40,410

$55,000 - 40,500 = $14,500 remaining

I arrange for base pass for Ken Pederson

10:30 At a loss what to do about packer - request Gary & Richard to call offices and get Dom Dea & Dom Poore to come out & discuss options.

To Page No.____

Witnessed & Understood by me, | Date 4/25/91 | Invented by | Date

Recorded by

From Page No.

11:30 Tom Dea and Tom Poore arrive onsite. Discuss options, decide to try to open valve above tool by turning 4 turns to left. Do this, open valve. Now, will jet water to dislodge loose fill material and attempt to raise packer.
Try this, doesn't budge.

12:45 Drop sounding line thru packer, find that gravel in well to 232 feet. Packer is at 221 feet.
Sound top of gravel above packer - is at ~~200~~ 158 ft, was at 162, so is coming up in hole. Later - measurement error

14:00 Decide to send Halliburton home until we get everything resolved. Re-tag fill at same levels as before.
Tom tries to arrange for video for 4/26.
Halliburton & Layne pack up & clean up to leave site.
I ~~go see~~ call Alex and explain what's going on.

15:10 Cut power (throw switch) to street light - concerned that crane is too close to line - they had no choice but to set up there, to maintain hold on tools/piping downhole.
Layne cleans & decons.

Friday, April 26, 1991

Layne cleans sites, moves gear back to yard in Woodland. Video survey of Bw-1
I meet w/ Tom Dea, Loyd Wells, Tom Poore, Richard Ballard - review video, discuss approach. Video doesn't show damage to casing, does show top of sediment. Decide to airlift sediment out of casing.

Monday, April 29, 1991

Gary & Mark work at ~~Bw~~ Cw-15D. I look at all wells. Talk to fire department - they agree to let me keep hose for 3 more weeks. Gary will scrape cement from ground at Bw-27.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	4/25/91 4/26/91 4/29/91	Recorded by	

TITLE Bw-1

Project No.

Book No.

From Page No.

Wednesday, June 19, 1991

11:00 Arrive onsite. Mark Lang, Rick Boyette, and Ron Hutchins of Layne Western are setting up at Bw-1. They have obtained base passes, and need a welding permit. I go find Fran, who says he's arranged for welding permit. I see Lorraine, and go to Pass + ID for new base pass.

12:00 Return to Bw-1, and find that fire inspector still hasn't arrived. I drive out to fire dept., and they inform me that inspector will arrive shortly.

1:00 Fire inspector arrives and issues welding permit, but informs us we need to contact Chief Gomez before we can use a fire hydrant. Layne begins welding piping to portable tank. I contact Chief Gomez, who agrees to send someone out to turn on fire hydrant.

Mark sounds hole — top of sand at 161 ft., obstruction beneath packer at 231.5 ft. Sounds top of filter pack inside conductor casing — it's at 71.6 feet.

Calculate volume of gravel from ground surface to 71.6 feet inside conductor is ~ 123.9 ft^3

(casing dia. = 12", cond. casing = 24" from 0-39 feet, borehole = 18" from 39 ft - 71.6 ft.)

This is enough to fill ~ 158 feet of 12 inch casing, or the 60 feet above the packer, plus ~100 feet below (not enough for 350 - 231 = 119 feet, but close)

2:30 Firemen arrive, authorize us to attach hose and turn on hydrant when we need to. Layne continues setting up. I drive out to fire station and borrow more hose.

3:30 I leave site for day, while Layne continues running in pipe + setting up. Will begin airlifting tomorrow.

To Page No.

Witnessed & Understood by me,

Date 6/19/91

Invented by

Date

Recorded by

TITLE BW-1 Project No.
Book No.

From Page No.

Thursday, June 20, 1991

08:00 Arrive onsite. Layne present, connecting airline pipe - should be ready 1-2 hrs.
08:30 I go talk to Fran on disposal of cuttings - express my concern on costs of drumming. He checks on alternatives, I call Rob and ask him to check on alternative disposal options.
09:30 Begin adding water to well to develop head, increase submergence.
09:40 Begin airlifting - appears to be working - water & sediment being lifted up out of the hole. When drop to bottom of 1st joint of pipe, try to add a joint. However, sediment comes in on pipe (or settles out) & locks in place. Raise pipe a few feet, restart compressor, airlift back down a bit circulate for awhile - let sediment settle and be removed.
10:45 Tank getting full of water. Start "trash pump" and pump water back down the hole.
However, have difficulty adding new lengths of pipe, because of stickup of tremmie pipe - in the way, can't unscrew sections & add sections.
11:30 While they're working on problem, I return to office. (Decide to obtain roll-off box to contain samples)
13:45 Return to BW-1. Drillers are successfully airlifting. Are down 30 feet. I drive to find out where soil vapor people got their roll-off box, make phone calls, etc.
15:00 Return - things going smoothly. I draft letter to Bruce on extra costs for soil containment.
15:30 Stop producing water & sediment, because now unable to maintain full head of water in hole, even with valve on fire hydrant wide open. Mark says compressor only 195 cfm - I feel we should have a 375 cfm unit.
16:00 They decide to pull up and keep trying. I return to office.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	6/20/91	Recorded by	

From Page No.__

Friday, June 21, 1991

08:00 Arrive onsite - drillers not here. Go call Layne, Tom says they had to buy some parts.
08:30 Drillers arrive - replacing airline, removing a section of pipe - think they are plugged (buried) in hole. Mark cuts off tremmie pipe sticking up in the hole to improve access to eductor pipe.
Top of gravel pack at 74.4 ft.
9:00 Begin circulating again - had to raise pipe about 14 feet from yesterday.
9:30 Rob arrives - we discuss budget, etc.
9:45 Loyd Wells & Tom Dea arrive - We discuss plugging hole, problems.
10:30 Alex, Mark Malinowski and ? from DHS arrive - we bring them up to speed on progress.
11:00 DHS & Alex leave. Continue airlifting. Down to 190 feet (made up for hole lost last night).
11:30 Gravel pack down to 79.3 feet. Turn on fire hydrant full, only raise water up to about 103 ft (static ≈ 110 ft - only 7-foot rise)
Continue lifting gravel from hole, but eductor pipe not dropping. Worried that filter pack gravel moving into casing. Tag top of gravel again - has dropped 2 feet. (1:30 - gravel at 86.6 feet).
1:45 Gravel locks up pipe. Necessary to raise up 10 feet - lost all progress made since last addition of pipe
2:00 Gravel pack at 88 feet.
2:30 Tom & Loyd leave site.
3:30 Continuing to airlift. Gravel pack at 91.6 ft. Bottom of pipe at ~ 194 feet.
Volume of 1/2 cylinder (e.g., the tank) - 8 ft dia + 28 ft long is ~ 300 ft^3. About 1/5 full, or 5 yards.

To Page No. /

Witnessed & Understood by me,	Date	Invented by	Date
	6/21/91	Recorded by	

18" bore hole = 1.5 ft

radius = 0.75 ft

Volume of 18" Borehole $= \pi((0.75\ ft)^2) \times 1\ ft$

$= \pi\ (0.563\ ft^2$

$= 1.77\ ft^3/\text{linear foot}$ 1.766

Volume of 12" well $= \pi\ (0.5\ ft)^2 \times 1\ ft$

$= \pi\ (0.25\ ft^2)$

$= 0.785\ ft$

Volume of annulus from 18" bore hole to 12" well $= (1.766 - 0.785)\ ft^3/ft$

$= 0.98\ ft^3/ft$

$\approx 1\ ft^3/ft$

From Page No.

So, has removed about 5 yds material from well.
Vol. of annulus from 72 to 190 ft = 4.3 yds.
Vol. of casing from 160 - 194 ft = 1 yd.
Total = 5.3 yds.
So, may have removed most of gravel pack from annulus. Very little formation material is present in the Delta tank. Although top of gravel pack tagged at about 92 ft, may have bridging at some point (some pea gravel cemented by iron oxide or manganese oxide). Gravel slowly moving past bridge.

4:20 Compressor runs out of gas - airlifting stopped. When restart, find that pipe is stuck due to gravel coming down on it.

4:40 They will pull out a section of pipe & re-start further up hole. I leave site for day, return to office.

Witnessed & Understood by me, | Date 6/21/91 | Invented by | Date
Recorded by

Volume of 12" well = 0.78 ft^3/ft.

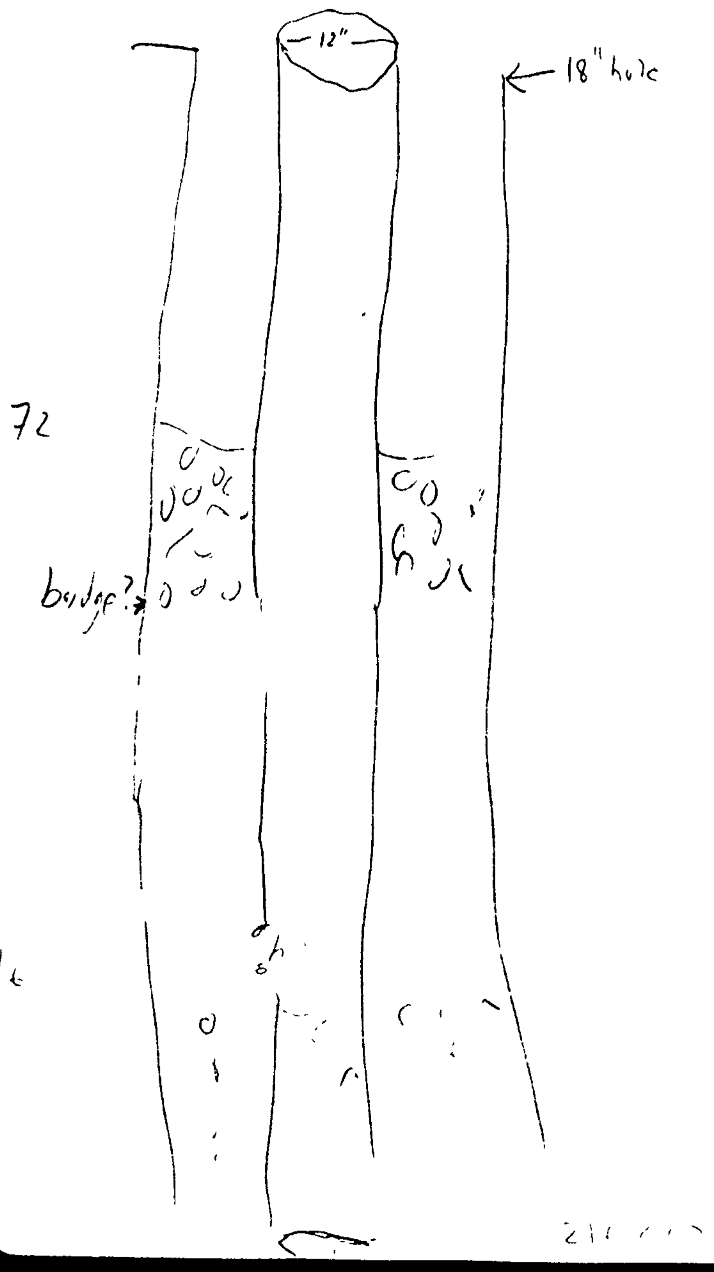
Volume of ~~18" - 12" casing~~ 18" bore hole - 12" casing annulus = 0.98 ft^3/ft

Gravel pack was at 72' and fill in well at 160 feet at start of air lift

160 ft - 72 ft = 88 ft of remaining gravel in annulus to 160 feet.

88 ft^3 of annulus space ÷ 27 ft^3 = 3.25

The gravel pack has not dropped as far as we thought it would so it may be bridging



From Page No.___ Monday June 24, 1991

Charles Elliot (704) 884-4566

Dorothy Loyd Atlanta (404) 998-6286

Call Halliburton every couple days

Layne has initial 50 hours through Wednesday June 26, plus ≈ 3500 allowance = 27 hours more to complete airlifting.

Note any Back hoe or TV work will be extra, keep records

Tom Dea 666-6023 Car 768-4970

Layne Western 662-2825

Removing gravel all day

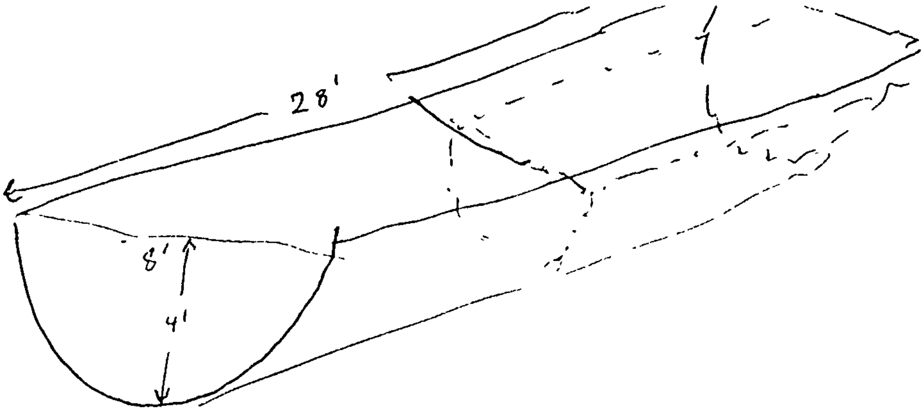
8:30 - 5:00 air lifting.

Time	Well	GRAVEL PACK
8:00	168.35	98.8
9:00		99.2
9:30	183.71	
10 30	186	99.8
11 30	187	105.4 - pluged off
12 00		105.1
12 30	189	105.4
14 00		106.4
14 30		108.3
5:00 ~~16 30~~	195	
16 30		110.4
17 00	204.65	110.4

To Page No.______

Witnessed & Understood by me, | Date 6/24/91 | Invented by | Date

Recorded by



Volume of gravel bin $= \frac{1}{2}\pi r^2 L = \frac{1}{2} \times \pi \times (4ft)^2 \times 28ft$

$= 0.5 \times 3.14 \times 16 ft^2 \times 28 ft$

$= 703 ft^3$

$703 ft^3 \div 27 \frac{ft^3}{yd^3} = 26$ cubic yards

Bin is filling to about 1 foot below the surface – asume walls are essentially vertical $1 ft \times 8 ft \times 28 ft = 224 ft^3 = 8.3$ cubic yards

Therefore, filling the bin to one foot below the surface gives $26 - 8.3 = 17.7$ yards.

As of 1:00 on June 24 the east end of the bin is full to about 1 foot below the top ~ (about $\frac{1}{2} \times 17.7$ yards $= 8.8$ yards $- \approx 0.8$ yards for the gravel being lower near the center ≈ 8 yards)

Volume removed from annulus $= (132.3 ft - 71.6 ft$ in annulus$) \times 1 ft^3/ft$

$= 60.7 ft \times 1 ft^3/ft = 60.7 ft^3$

Volume removed from well $= (161 ft - 217 ft) \times 0.785 ft^3/ft$

$= 56 \times 0.785 = 44 ft^3$

Total volume removed assuming an 18 inch borehole $= (60.7 + 44) ft^3 \approx 105 ft^3 = 3.9 yds^3$

This volume is less than $\frac{1}{2}$ of what we have pumped out !! therefore the bore hole was larger than we thought or there is a gravel zone in the well which has caved in.

TITLE Bw-1

From Page No.

Tuesday ~~the~~ June 25, 1991

Check volume of TANK on sep page

Time	Gravel Pack	Casing	
8:00	126.2	183.6	
9:30	130.2	206	
10:30	131.2		← tool got stuck and bridged
		190	well filled to 190 feet then
10:40			green hose came up at 10:35
12 00	130.9	210	← Hose coming up
12 30	132.3		
1:00		217	
2:00		220	
2 10		221	

Pulled up the packer about 14 feet and now it is stuck. The rig wouldn't move the packer at all until they moved the rig closer to the well

Call to Tom Dea — sound on 1 outside and 2 inside of casing and 3 through the top — 225 feet

Try rotating packer.

Mark Long could move the packer down a couple feet but could not raise it

3:00 start air lifting again — some sand coming up.

Two pieces of green hose came up!

Mark worked the packer up and down and raised it ≈ 15 feet

— Layne is bringing out more equipment so we can pull the tools tonight.

Total gravel in bin is ≈ 12 ~~13~~ yards — 1 foot below the top on the east side and 2 feet below the top on the west side.

this is ≈ 3 times the amount which would come from an 18" hole

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	6/25/91	Recorded by	

Project No.
TITLE Bw-1
Book No.

From Page No. Tuesday June 25

4:00 Called Vicki at Delta Oil Field Service for another 25 yard tank
662-2841 - Vicki Wilson at Delta Oil Field Service
PO BOX 1675 Woodland
Corner of east and kentucky.
$25/day plus 70/hour for delivery.

4:40 welder arrives from Layne - fabricating slip plates to remove the air lift 4" discharge line and couplings

5:15 Start pulling out air line and packer - raised packer to ≈ 206 feet
- pull out 2" air line (≈ 180') from inside 4" discharge line.
pulled out a ≈ 20 foot legnth of support tubing for the packer
6:00 - start pulling ≈ 200' of 4" discharge pipe for air lift discharge.

7:10 - Pulled packer up a few feet and then it stopped - it will rotate but will not come up. - could be bad casing.

	Packer	GRAVEL PACK
7:40	199.7'	129.3

8) leave site

Wed
8 30 196.9 —Sounder got stuck

To Page No.

Witnessed & Understood by me, | Date 6/25/91 | Invented by | Date
Recorded by

From Page No. Wednesday June 26

- Put air line back down hole - 2.8 feet of material had fallen onto the packer overnight

- Air lifted material down to where we thought the packer was then went ≈ 2 feet lower - Lloyd of Layne's Field superintendent thought the air lift pipe had previously been on top of the sub fitting and now was going down to the packer

1:00 - Tried to pull up packer while still air lifting - Bent the derrick on the crane. - Broken down - lost extention on crane bent
Packer had moved up and down a few inches (see drawing opposite)

The crane had been under a larger strain last night and had not bent then - perhaps it was weakened

1:30 - Lloyd ordered a SMEAL pump rig from the Layne yard in Woodland should be here in an hour - we may need a rated crane at some point to have 2 lines.

2:00 Need to see from slavich, Delta arrived with a second 25 yard bin,

Mark Malinowski said to take 1 TLCP sample of the gravels

He Mark said it was ok to put gravel back down the gravel feed tube

2:30 SMEAL RIG on site - setting up to pull

Well GRAVEL PACK

3:30

1 3 2.2

lifted airline 28 inches and welded tabs on it so it is now at the level we originally thought the packer was at this morning. We don't really know why the air lift tool went 28 inches below where we thought it would.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	6/26/91	Recorded by	

Project No.
TITLE Bw-1 Book No.

From Page No.

3:45 The smeal Rig will pull more than the Pitman Hydra lift crane on the other rig. However - the packer will not come up.
Continue air lifting till 5:00

Thursday June 27

Drillers on site 8:30 - Sound well - start air lifting - air lift line jams.

Time	Sand In Casing	Gravel pack level	Difference from yesterday
8			
830	184.1	140.4	-14.7 feet for gravel
1130	189.98		+12.8 feet for well
12:30		142.1	
1300	192		
14:30	208.8	143.0	
16:30	203.04		
1700		143.6	
1830		144.3	

Note: The packer may be deeper than we thought it was. According to Mark's measurements of the air line 4" pipe is 201.04 feet below the cement well pad.
We aren't sure how deep the packer really is. It was originally reported as being ≈220 feet originally - They pulled up a 20 feet length of packer support pipe on June 25, 1991

The packer support tubing is typically 23 feet long - 10 joints would be 230 feet. The subs and valve to the packer are ______ feet long.

Page 54 indicates the packer was originally stuck at 221 feet.

To Page No.

Witnessed & Understood by me, | Date 6/27/91 | Invented by | Recorded by | Date

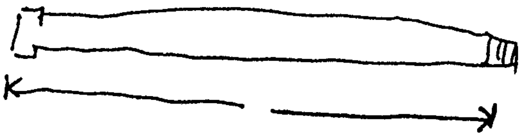
Packer tubin

Joint # app length

1 19'3" ≈ ~~18'7"~~ (6' stick up when we got stuck originally)

2 (6/28) 24'6" (pulled up evening of 6/27 removed morning of 6/28)

3 6/28 25' (pipe measured from collar on one end to half way up threads on the other



4 25'1"

5 25'1" there is a rust mark on this pipe the packer came free when the 5th joint was raised ≈1 foot above the slip plate, - Rust mark 9' from bottom of pipe,

6 24'

7 24'7" Gravel on bottom ≈ 5' of pipe

8 25'

9 25'2"

5'6" 6'1" 5'6" to top

(total length of sub + packer

223'1" — distance from pad to where packer was stuck.

TITLE 6/27 - 6/28/91 BW-1

Project No.

Book No.

From Page No.

3'6" + 20'9" - 5' = 24'3" - 5' = 19'3"

17:30 — !! Pulled ~~up the~~ the packer up 20 feet.

We need another crane - (taller) to remove both the air line and the packer string. - Hank DeWet should be able to come out in the morning with a hydro crane

1830 Left site

Friday June 28,

Hank DeWet on site with a hydro crane which is taller than the Smeal. He will be able to pull out the air line once the hole is clear

9:30 Air line discharge is clear now - Pull up 5 feet on the packer string, to the ~~break in the~~ joint in the 2 7/8" tubing. Remove the 2nd joint of packer support pipe and a joint of 20 foot air line. The packer pulled up fairly smoothly so Mark

10:00 Long is confident we can pull up the rest of the packer string. Therefore we will pull all of the air lift string.

(lifted the 2nd joint ≈ 6" from where we were last night

Mark thinks the tool was originally stuck at 225 feet.

- We have pulled up ≈ 40 feet of packer tubing

11:00 Removed 3rd joint of packer support tubing 25'

4th joint 25'1"

11:20 Removing 5th joint - the packer freed completely when Mark Long raised it 1 foot above the slip plate. Rust mark 9' above the bottom. 25'1"

11:30 Remove 6th joint 24'

Well tags at 218 feet after pulling packer

11:35 remove 7th joint 24'7"

11:40 remove 8th joint 25'

11:45 remove 9th joint 25'2"

1150 remove PACKER + sub !!!

To Page No.

Witnessed & Understood by me,

Date 6/27/91 6/28/91

Invented by

Recorded by

Date

TITLE Bcw-1 Project No.
Book No.

From Page No.

Well tags at 218 feet - assuming 400 foot total depth gives 182 feet of gravel to airlift out × 0.785 ft³/ft = 143 ft³ of gravel to remove = 5.3 yards.

1432 - Gravel pack tags

13:30 Call Chuch 704 884-4566

Tom DEA - Layne 666-6023 662-2825

Monday July 1
Laynes Totals (146549 billings through April)
June 17 to 28, 1991 Tom Deats Billing numbers

Mob/demob 4800 -		4800
Airlift 48 1/2 (assume ave $130/hr)	=	6305
estimate 60		
Travel 12 3/4		1071
estimate 12		
Superintendent 16 × $68/hr		1088
estimate 20		
Decon 0		
estimate 6		
Drilling Fluid 0		
estimate ≈ $1200		
Portable Tanks (2)	≈	500
estimate 8 days × 25/day		
Air Compressor - 7 days		2226
6 days at 318/day.		
		34,919

To Page No.

Witnessed & Understood by me,
Date 6/28/91 7/1/91
Invented by
Recorded by
Date

Project No.____
TITLE ____ Bw-1 ____ Book No.____

From Page No.__ Monday July 1 - Rob Pexton

8:30 TV Truck on site - start setting up - Eric Vincent of Layne Western.
9:30 Start video log

DEPTH	
12	Joint in casing - vertical striations from scratching casing.
30	Joint in casing
50	" "
70	" slight lip on joint
90	"
93	Start Mills knife perforations 4 per foot 90° apart - need to check size.
111	Static water
112	Joint in casing
133	Joint in casing
153	"
165	~~Rip~~ Hole in casing - 8 and 10 o'clock.
167	hole in casing 9 o'clock.
168	small hole in casing 7 o'clock. Note tool was sticky coming out for 75 feet up from 223 feet.
173-9	THIN break in casing
179-182	Rip in casing ~~to~~ 12:30 - clay in bottom. Wide.
185-84	~~Hole~~ Break in casing with green hose init 12:30
186	" another piece of hose
187-189	Casing is split 185 down to 189 10 pieces of hose.
191	Joint in casing.
211	Joint in casing
215	Fill in Well

To Page No.____

Witnessed & Understood by me, | Date 7/1/91 | Invented by | Recorded by | Date

TITLE BW-1

Project No.
Book No.

From Page No.

10:15 Run second log with 90° camera mirror to look directly at the side of the casing

164 Tear in casing - can see gravel
165 2 Tears in casing parallel to each other.

168-9 Breaks in casing with gravel showing.

172-3 Narrow break in casing
174 - break shifts over
175-180 break continues straight - can see gravel behind it - narrow

180 piece of gravel
181 hose piece
182 3 pieces of hose

183 1 piece
184 3 pieces
185 3 piecs

186 Large hole 3 pieces?
18
188 1 piece

189 Second crack starts.

191 Joint in casing.
192 New hole at 191-192

NOTE: The green hose was dropped down the gravel feed tube when the top of the gravel was around June 21 - 79 feet - now the gravel hose is coming through around 180-190 feed. Has that much gravel pack been removed?

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	7/1/91	Recorded by	

Project No.
TITLE BW-1 Book No.

From Page No. Monday July 1, 1991

11:00 Remove camera, start installing air lift tools - will try to air lift material out of well from 215 to 400'

11:10 Eric Vincent leaves with Video Truck

We don't know what condition the casing is in below 214 feet. It is likely that there are breaks in the casing both around 221-223 feet where the packer was jammed and possible holes below 223 feet because the well filled in below the packer.

The well tagged at 231 feet when a sounding line was dropped through the open valve on the packer sub tool. That indicates 170 feet of material had filled the well from 400 to 230 feet, below where the packer was stuck.

I'm not sure what the pieces of green hose blocking the crack around 180 feet indicate. The gravel pack was ≈79 feet when the green pieces of flat 2" hose ≈ 2" x 2" x 1/4" were poured in the gravel feed tubes. The green pieces started to come out of the airline discharge pipe around 10130 ½ noon on June 25 when the gravel pack had dropped to 131 feet and sediment in the well was 190-200 feet during air lifting.

That would suggest that as the gravel pack surface dropped from 79 feet to 131 feet, a total of 52 feet. The hose pieces had dropped from 79 feet to 180 feet or 100 feet.

If the hose pieces just sat where they were relative to the gravel then about 50 feet of formation material fell on top of the pieces of hose as the gravel pack was airlifted out of the well through the breaks in the casing from 168 to 188 feet.

However the hose could have fallen down preferentially if the gravel pack is somewhat fluid or circulating during air lifting.

Gravel pack level was 143.2 feet Friday afternoon

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	7/1/91	Recorded by	

TITLE BW-1

Project No.

Book No.

From Page No. July 1, 1991.

The well only filled from 218 to 214-15 over the weekend. The green pieces of hose have blocked off some of the cracks reducing the amount falling in from ≈10 feet over-night to ≈3-4 feet over the weekend

12:40 Airline tool string in well - Tag gravel ~~before~~ after starting at 140.4 start airlifting

Will Row of DHS wants to see the video

Need to meet with Fron Tuesday morning

2:40 - 3:00 air compressor down

3:00 Gravel at 147 ~~Well~~ Material caved while air compressor was down for 20 min when air lift tool was at 226 feet
Raised air lift tools to 196 feet in order to free them
~~Gravel at 147.~~ resumed air lifting.

Note: air lift mainly picking up sand with little gravel - looks like the sand on top of the packer.
Drillers were getting gaps in air lift production - couple of 3 foot gaps which may be bridging -

We don't know why the gravel level dropped from 140.4 to 147 when only a little material was air lifted out - there may be a void below

4:00 Airlifting with pipe at 216 when material fell in again
Had to raise pipe to 196 feet to clear it.

4:30 Gravel pack tags at 147.7 well is at 191

⇒ Material probably comming in from the borehole - will let water in 26 yard^3 trough settle overnight.

To Page No.

Witnessed & Understood by me,

Date 7/1/91

Invented by

Recorded by

Date

From Page No. July 2, 1991

Gravel pack tags 145.5

Drillers (Mark Long, Ron Hutchins + Rich Boyette) are having trouble clearing the air line. Have to raise the air line ≥ 30 feet to free it. We are airlifting sand which indicates the borehole is caving. I haven't seen any more pieces of green hose.

We may want to consider sealing the anulus by putting in ~~the very~~ bentonite pellets or very thick cement with lots of calcium chloride down the gravel feed tubes to fill up the annulus.

Once the annulus is sealed we will be able to airlift out the material in the well casing from ≈ 180 to 400 feet.

Mark is lowering the airlift pipe in ≈ 1 foot increments and waiting for it to run clear before moving it down.

Gravel tags 146.1 – We started adding several hundred gpm of water from the fire hydrant which improved air-lifting dramatically – lots of gravel is coming up now. Perhaps the increased available flow is picking up the gravel. I doubt the ≈ 2 feet of head will do much maybe the airlift just needs more available water in the casing because the well will not produce much water with most of the casing filled in

July 3, 1991

Call Tom Four – Halliburton

Call to Tom Dea – He suggests using hole plug.

2:00 Tools at 212

2:30 Tools at 222.45 Gravel pack at 148.7 Temp 109?

3:30 Tools at 232.45 Gravel at 150.5

5:00 Tools at 232.45 Gravel at 150.7

To Page No.

Witnessed & Understood by me, | Date 7/2/91 | Invented by | Date

Recorded by

TITLE BW-1

Project No.

Book No.

From Page No. July 3, 1991

Well tags at 228.02 ft, up 4 feet of fill from last night (230.220) start airlifting

Gravel pack tags at 191.3 feet - down ≈ 45 feet from last night - The gravel was probably bridged at 145 feet and the bridge collapsed overnight.

When they were circulating at 230 feet ~~to~~ yesterday afternoon - a large amount of gravel came in - this may have been coming into the well through the rip in the casing from 180 to 184 feet. - removing that gravel may have caused the bridge to collapse overnight.

The gravel level is now below the main tear in the casing which we saw on the video log run from the surface to 215 feet

However there may be a tear around 221 feet where the packer was stuck originally. We tagged below the packer when the packer was stuck at 221 feet and hit material at 231 feet.

10:25 Airlifted down to 245 feet in the well, circulated to clear out material, then pulled up 40 feet (put 40 feet of pipe on the ground). Drillers will go to another job until Tuesday July 9

9:00 Met with Capt. Slavich and Mark Malinowski of DHS who inspected the operation. DHS wants the well grouted from the bottom to the top. They don't know what the vertical distribution of contamination is in this area.

We can put gravel pack back down the well once we have grouted above the breaks in the casing.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	7/3/91	Recorded by	

From Page No.__

NOTE: DHS wants copies of all the video logs run for the well abandonment project.
DHS wants TCLP and TTLC volatile organics tests run on one gravel sample

10:45 Gravel packs a 204.7

11:00 Crew shuts down for 4th of July weekend - Back tuesday July 9.

~~Dr~~ Mark Malinowski doesn't expect to find anything in the gravel but recommends testing it so we have a record that there isn't anything there. He was concerned that the casing had been perforated from ~~8~~90 feet down without consulting DHS.

If worse comes to worse we could grout the well up from as deep as we get (ca 250') to ground surface - perhaps with an 8" liner inside the 12" ~~csg~~ casing. Then we could come back later and drill through the cement plug and remove the material below say 250 feet.

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	7/3/91	Recorded by	

TITLE Bw-1 Project No.
Book No.

From Page No. July 9, 1991

915 Mark, Rick & Gary arrived w/ rig & started setting up.

930 Left site to get hard hat. Rick gave me daily logs for 7/1 to 7/3

1010 Rick said they hit gravel pack at 208.3 ft.
Tools down to ~~Now at~~ 248.45 ft a loss of 5.00 ft since 7/3/91.

1030 Delay due to leak in the hose. Patched it up & continuing to airlift.

1100 Down to 253.45 ft in well. Stopped airlifting to add extension pipe.

1205 Down to 274.70 ft in well.
Next one down will bring it to 296.70 ft.
Gravel pack at 207.3 ft.

500 pm Tools at 334 ft
Gravel pack at 207.3 ft

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	7/9/91	Recorded by	

From Page No.

Wednesday, July 10, 1991

7:45 Arrive onsite. Work on budget while waiting for drillers to arrive. (Return to office, pick up phone).
8:30 Drillers arrive. Tag gravel pack in annulus at 207 feet, gravel in casing at 334 feet. So - no ~~&~~ sediment has come in over night - hole seems to be stable. Continue to airlift sediment from hole
13:00 Down to 365 ft. Sediment coming up dark - original sediment from bottom of hole?
Halliburton will arrive at 2:00 to secure base passes. Return tomorrow A.M. to begin cementing BW-1.
This morning, I asked Alex to research where we can move bins of gravel.
14:00 Halliburton crew arrives - says they can fit rigs onsite without necessitating removal of bins of gravel. Captain Slavich arrives at 14:00 also - he's arranged a place for us to move bins, but we tell him we don't need to move them. Halliburton crew sees Lorraine for passes - then goes to Base Pass facility. Lori, Tom Poore and I discuss cementing strategies.
15:00 Halliburton leaves
16:00 Mark + crew reach bottom of well at 395 ft. Circulate for awhile, then pull up a few feet. Secure gear.
16:30 I return to office.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	7/10/91	Recorded by	

TITLE BW-1 Project No.
Book No.

From Page No.

Thursday, July 11, 1991

8:30 I arrive onsite. Layne is present - BW-1 remained stable over night, + no sediment came into well - Layne is pulling out the airlifting pipe.

Calculation of Cement needs (below damaged casing)

~~Hole~~ Casing diameter = 12"
Borehole diameter = 24" (assume same as conductor casing)
Assume 40% volume in gravel packed annulus
Casing vol. = 0.79 ft³/ft
annular vol. = (0.40)(2.35) = 0.94 ft³/ft

Total = 1.73 ft³/ft

So, to rise 50 ft., need 86.50 ft³ cement, or 15.5 bbls.

Bottom of well tagged yesterday at 396 feet. So, 15.5 bbls should seal up to 346-foot-depth.

9:30 Halliburton crew arrives. Richard Ballard, Bill Lacey, John ?. I facilitate moving of vehicles of workers inside adjacent building - Halliburton maneuvers their pump rig + bulk rig out side BW-1 building. Layne continues removing eductor pipe from well.

10:10 Finish pulling out pipe - begin installing tremmie pipe. (Sun goes into eclipse)
(I call Suzanne to come out to site)
11:30. Finish installing tremmie. Begin making wellhead connections. Richard will pour 50 sacks, or 17 bbls.

* Goal - Set up at (395 - 55.2 = 340 ft.)

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	7/11/91	Recorded by	

Project No.______
TITLE Bw-1 Book No.______ 78

From Page No.__

1215 Capt Slavich visited the site. He wanted to know if we were going to fill up to the gravel pack today. Mark & Richard told Capt Slavich that the well had perforations except for the top 85 ft. Richard said they were aiming to put 100 sacks down. Capt Slavich wanted to know how much (in feet) of the well was going to be grouted. Mark & Richard didn't think we would fill up to the gravel pack. Capt Slavich said his concern about the pack was based on a meeting w/DHS. ~~[illegible]~~ He wants Chuck E. to call him so he can discuss this further.

1230 Started adding water to Halliburton's water tanks. ~~[illegible]~~ Did not get the water connection fitting. Will start placing cement when the desired weight is achieved

Note: Richard & Mark wanted to know how many sections of pipe would need to be pulled. They are planning to pull 4 sections.

1300 4 sections of pipe were removed from the well.

1320 Cement mixture is added to the well. Both crews are now taking breaks while they wait for the cement to set

15:00 Rob & I return to site. Go with Dom Poore to meet with Capt. Slavich, but encounter Fran & 2 DHS people (Wendy ? and Wayne (?)). Return to Bw-1 and discuss site - They're interested in what we're going to do, esp. at damaged part of well.

15:30 They leave - tag top of cement at 205 ft. So, raised 120 feet. Very concerned that no cement going to gravel pack. Halliburton rechecks notes, and discovers that miscalculated water added to mix (Note: Calculate amount of cement mixed by measuring volume of water added to achieve a

To Page No.______

Witnessed & Understood by me, | Date 7/11/91 | Invented by | Date | Recorded by

given density).
Calculations:
Matrix water requirement = 11.3 gals/sack
(cement = 1 ft^3/sack at 94 lbs/sack)
used 23 bbls water
Goal - slurry density = 12.7 lbs/gal.
Used 85 sacks by mistake, instead of 50 sacks.
Conversions from sacks to volume of cement:
sacks x 1.97 = yield in ft^3 x 0.1781 = yield in bbl
So:
(85 sacks)(1.97) = 167.45 ft^3 cement
This would ideally raise plug to:
$167.45\ ft^3 \cdot \frac{1\ ft}{1.73\ ft^3}$ = 97 feet at 40% porosity
(or 112 ft at 30% porosity)

Tagged at 275 ft., so rose 120 ft - not perfect, but adequate.

16:30 Pump another 15 sacks of matrix, for a total of 100 sacks for the day. This should yield
(15 sacks)(1.97) = 29.55 ft^3 cement.
Should bring up 17.1 ft at 40% porosity
or 19.7 ft.

17:30 Rob & I leave site - Layne & Halliburton finish up, secure site.

From Page No.__ Friday, July 12, 1991.

7:45 Arrive onsite. Layne & Halliburton present – have tagged cement at 231 feet bgs, and set tremmie pipe at 221 feet. Halliburton mixing 50 sacks of Matrix to pump downhole. (Cement came up too far last night – ~~...~~ even though kept water from hydrant moving downhole all night).

Estimate of rise: (50 sacks)(1.97) = yield of 98.5 ft^3

Would rise from 57 ft (40% porosity) to 66 ft (30% porosity)

However, after it reaches about 190-foot depth (31 ft rise) will begin to flow into the void space left by gravel pack.

Assume 40% porosity, gravel pack at 207 ft.:
From 207-221 feet will use 1.73 ft^3/ft, or 24.2 ft^3 of cement. Above 207-ft. depth, will use about 3.14 ft^3/ft (24-inch borehole – all empty).

So, 50 sacks will rise another 24 feet, or (207-24) = 183 feet. Should tag around this depth.

8:30 Finish adding washup water to hole, allow to set up. Add head of water.

Mark measures cement in BW-12 at 52.5 ft.

10:00 Dean drops by – discuss options. He'll check w/ DHS on adding cement to annulus.

12:00 Tag cement at 193 feet. Confirm that cement is at this same level in annulus by running sounding line down the gravel feed pipe. Begin mixing another 50 sacks of Matrix. Should bring it up another 31 feet, to 162-foot-depth.

12:45 Begin pumping cement, then clean up and apply head of water. Wait to set up.

15:25 Go ahead & tag (we're just filling an empty hole, so even if hasn't set up completely it should be okay to pump more cement). Tag at 162 feet!!

To Page No.____

Witnessed & Understood by me,	Date	Invented by	Date
	7/12/91	Recorded by	

TITLE Bw-1

Project No.

Book No.

From Page No.

Because of uncertainties regarding amounts pumped in different lifts, I check again for reasonableness:

So far:
Pumped (200 sacks)(1.97) = 394 ft³

Vol. of well from 395-207 feet at 40% porosity is:
(188 ft)(1.73 ft³/ft) = 325 ft³
(69 ft³ remaining)

Vol from
207-162 = 45 ft = 141 ft³ - but only 69 ft³ left
This is enough to raise it 22 feet - so total of 23 feet off in lowermost 233 feet (10%).

If casing is 12" and borehole is 18".

Vol of well from 395-207 feet at 40% porosity:
0.39 + .79 = 1.18 ft³/ft.
So would take 222 ft³.
207-162 = 45 ft @ 1.77 ft³/ft = 79.5 ft³
total would be 301 ft³. This would imply substantial losses to formation.

16:00 Begin pumping 100 sacks of Maxxim. This should raise top of cement (100)(1.97)/3.14 = 63 ft, or to depth of (173-63) = 110 feet.
(Pull tremmie up, pump wash water downhole)

16:30 Dom Lovro arrives - agrees to top off Bw-12 (w SR?) w/o additional mob + setup charge.

17:00 Finish pumping washwater. Add head of water, clean up, secure gear, set barricades at Bw-12.

17:30 Leave site for the day

To Page No.

Witnessed & Understood by me, | Date 7/12/91 | Invented by | Date | Recorded by

Note: Much uncertainty regarding amount of Matrix pumped per lift.

Reality check

As of 7/15 in A.M., top of cement is at 127.5 feet.

Know we have used 300 sacks to this point, or
$(300)(1.97) = 591\ ft^3$.

Volume to fill 24" borehole w/ 12" casing from 396' to 207 feet assuming 40% porosity is:
$(396-207)(1.73\ ft^3/ft) = 327\ ft^3$

Volume to fill 24" borehole from 207 feet to 127.5 feet at 100% porosity (no gravel pack) =
$(207-127.5)(3.14\ ft^3/ft) = 250\ ft^3$

total $= 327 + 250 = 577\ ft^3$

So — About right so far.

From Page No. Monday July 15, 1991

Well 1 Tag gravel pack and well at 127.5 feet. = Lower than the 110 feet predicted based on a 24" borehole. This indicated Water level 102 feet.

Well 12 Tag cement at 51.8 feet below the pad (pad is ≈ 10 feet below ground)

52 ft of 14" well

$$\left(\frac{7}{12}\right)^2 \times \pi \times 52 = 1.06 \frac{ft^3}{ft} \times 52 ft$$

$$= 55 ft^3$$

(yield of Pozmix ≈ 1.26 per sack)

∴ need about 44 sacks

On Bw-1, raise in 2 lifts. 1st lift cement to 100 feet. will need (127.5 − 100) = 27.5 ft needs or ~86 ft^3, or about 69 sacks.

12 bands and 105 barrels - Halliburton's counter starts at 1

Plan top of well 12 then well 2 then fill well 1 about to the water level

We would like to put some of the cement down the feed gravel feed pipe.

CITY WELL 150 - Needs to be topped off by Layne tomorrow to ground surface. The air line needs to be taken to DRMO

EASF Well 27 - Need to top of ≈ 10 feet of 6" well casing

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	7/15/91	Recorded by	

Bin 1 is about 1.5 feet below the top, Bin 2 is about 2 feet below the top

n 1 $8 \times 28 \times 1.5 = 336\ ft^3$ missing

n 2 $8 \times 28 \times 2 = 448\ ft^3$ missing

Each bin is $\frac{1}{2}\pi r^2 h = \frac{1}{2} \times 3.14 \times (4ft)^2 \times 28\ ft = 703\ ft^3$

$= 26$ yards ~ call it 25 yards

Bin 1 $703 - 336 = 367$

Bin 2 $703 - 448 = 255$

$622\ ft^3$

Therefore the total volume of gravel removed was $\approx 622\ ft^3 \approx 23\ yards^3$

Well volume from 160 ft → 400 ft $= 240\ ft \times 0.785\ ft^3/ft = 188\ ft^3$

Gravel pack volume is roughly 40 to 207 feet = 167 feet.

$622\ ft^3$ total gravel removed $- 188\ ft^3$ from casing $= 434\ ft^3$

$434\ ft^3$ gravel pack removed $\div$ 167 feet $= 2.6\ ft^3/ft$ of annulus

24" borehole annulus with a 12" well would be $(3.14 - 0.785)\frac{ft^3}{ft} = 2.36\frac{ft^3}{ft}$

Project No.________
TITLE BW-1 Book No.________

From Page No.__ July 15, 1991

10:30 Topped off Well 12 to top of well pad (52 feet)

10:45 Topped off Base Well 2 ≈ 8½ feet

11:00 Mark Malinowski, and __________ of DHS and Jerry Robbins of McClellan AFB on site with questions about abandonment.

14.1 lbs/gal (50/50 Pozmix; 2% gel; 3% CaCl)

Halliburton pumped ≈ 16½ Barrels = 693 gallons ≈ 93 ft^3

If the borehole is 24" diameter $93 ft^3 \div 3.14 = 29.6$ feet of ~~only~~ well casing and annulus will be filled, which would raise the cement level from 127 to ≈ 97 feet.

11:50 Water level at 97 feet inside and outside casing.

12:10 Water level 100.5 feet, " "

Setting packer at 75 feet - will pump ~~35~~ 3½ barrels of water through the packer on top of the cement.

12:30 Could not force packer into casing. Decide to quit trying (afraid to get it stuck). Turn on hose, put head on well.

Note: Mark, Will & Jerry had previously visited site - wanted us to set packer at this point to ensure cement moving through casing.

12:45 Adding water through fire hose - raises water to 88 feet with fire hydrant on full. (Came up to 128')

14:00 Meet with Jerry - call Will Rowe at DHS to explain about the packer. Agree to call him back after tagging TOC. Water level 74 feet.

14:45 Tag cement in casing at 113.2 feet. Tag in annulus within 4 inches (113.6 ft)

15:00 Call Will Rowe, discuss approach. Decide to Dump up to 85 feet, then add head of water. To Page No.______

Witnessed & Understood by me,	Date	Invented by	Date
	7/15/91	Recorded by	

to "push" cement down
Volume cement needed:
(113.6 − 85) (3.14 ft³/ft) = 90 ft³
So, 90/1.26 = 72 sacks cement

15:30 Add tremmie pipe to 105 ft.
16:10 Finish adding ~~cement~~ pipe, begin adding cement.
16:30 Cement (90 ft³) and wash water have been pumped. Add head of water, secure site.

16:38 Water level 85 feet.

17:00 Everyone leaves site

TUESDAY JULY 16

Cement tags at 111 feet ☆!☆!!
Water level 100.05 feet.

We will pump 75 sacks of posmix cement initially. The first 30 sacks or so will have flow seal added. (cellophane flakes)
Richard will mix it at around 15 lbs/gallon a thicker slurry than before.

Bruce Eades 643-3532 - Contracting officer
DHS Toxic Substances Alberta McMurray -
Croydon
Chuck x 279
Posmix is $10.50 / bag

As of 7/18 am $12,000 left in Layne Budget 19,000 spent
need to know Layne charges

Assume 8 - 12 hour days for Layne at 130/hr = 12,480
666-6023

TITLE Bw-1 Project No.______ Book No.______

From Page No.__

Need to know Halliburton costs through this mornings pour $22,345

9:15 pumped ≈ 17 barrels of ≈ 15.1 lbs/gallon posmix with flow seal, ~~2%~~ 2% bentonite and 3% $CaCl_2$ ~ no head added

Water level 87 feet shortly after pumping.
Flow seal added at ¼ lb per sack of cement

Yeild will be ≈ 1.07 ft^3/ft

15 barrels × 42 gallons ÷ 7.48 gallons/ft^3 = 84 ft^3.

84 ft^3 ÷ 1.07 ft^3/sac = 78.7 sacks 50-50 posmix.

Volume needed ≈ Assume 100 feet of 24" bore hole = 314 ft^3
Assume 30% loss to bore hole ~~63~~ 94 ft^3

~~377~~ 408 ft^3 required

Assume 408 feet^3 cement ÷ 1.26 ft^3/sac yeild fact.
= 324 sacks.

300 ft^3 ÷ 1.26 $\frac{ft^3}{sack}$ = 238 sacks

11:20 Cement soft tag at 107.5 down well

Water level 85.9 feet.

11:40 Soft tag at 106.5 feet down well

12:50 tag 101.8 feet - Drillers tag at 102.2.

1 45 Bulk truck on site.
84 ft^3 were poured

205 Tag at 99.5 feet - up 11.5 feet = 7.3 ft^3/ft.

To Page No.______

Witnessed & Understood by me, | Date 7/16/91 | Invented by | Date | Recorded by

From Page No.

Plan is to use 19 sacks of cal seal cement + 4.7 barrels of water to give 6.7 barrel slurry = 37.7 ft^3 cement or 12 feet in the hole at 3.14 ft^3/foot of 24 inch hole - this would nominally bring the cement to 87.5 feet - 2 1/2 feet below 85 feet (where the perfs start)

yeild of Cal seal is 1.98 ft^3/sac

2:15 Cement pumped (6.7 barrels) followed by 1 1/2 barrels to clear lines
water level at ~~87 feet~~ 85.5 feet
Run washup water down hole - water level rose to 81 feet.

Materials left

~~60 ft^3 dry cal seal which will make 118 ft^3 slurry = 21 barrels~~

30 sack call seal - which will make 60 ft^3 of slurry

79 sacks of pozmix which will make 100 ft^3
17.7 barrels

Total available is 160 ft^3

composition
Premium - 205x
Calseal - 25x
2% gel - 01
2% $CaCO_3$ - 21

Minimum required with 90 tag on first calseal batch is 188 ft^3
⇒ we are 28 ft^3 short

3:00 Cement tags 95.5 feet water at 81.8 feet

Minimum required is ≈ 204 ⇒ we are 44 ft^3 short

3:20 Realize that - due to large quantities of cement we're using - serious risk of going over budget. I call Stan and discuss the situation with him. We try to call Bruce Eades, but are unsuccessful. Decide to pour the last 100 ft^3 of Pozmix that we have on hand, since we've committed to using it. After that, we'll send everybody home until we've had a chance to discuss it with Bruce.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	7/16/91	Recorded by	

Project No.
TITLE Bw-1 Book No.

From Page No.

3:50 Cement tags at 94.7
Water level 84.9 feet
Before pouring 100 ft^3 of pozmix

446-3003 Layne Western in Woodlands -

4:00 Poured 100 ft^3 pozmix plus 1½ barrels of ~~wa~~ follow up water
water level rose to 65 feet.

4:04 Water 66.3 feet
4:07 67.8
Add washup water to the hole, send vacuum truck to EH.
Water level rose to ≈ 53 feet inside casing ≈ 66 feet outside
4:20 Finish Halliburton washup. Clean up & secure site
4:40 Everyone leaves site.

Wednesday, July 17, 1991

07:00 I stop to tag cement - TOC at 93.2 feet
*** (Note - All cement quantities in notes & Halliburton ticket agree, except for Pozmix. Notes - used 329 sacks. Ticket: 362 sacks. Multiply Pozmix amounts in notes by 362/329 = 1.10)

Wednesday, July 24, 1991

9:00 Arrive at Bw-1 and unlock building for drillers. Drive to locate Rob P. & Jeff K.
10:00 Return to well - wait for drillers & cement. Don't show up - call Dom, find they're having mechanical trouble. Will arrive at 1:00
1:00 Return - drillers & Abba Dabba cement present. Necessary to break sounder, previously stuck in the hole. (Rick & Gary)
Will fill annulus first ≈ 2.35 ft^3/67.
Tags at 93 feet
Larry (F.L.) Doyle of Mitre Corp. drops by the site & we discuss approach.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	7/16/91 7/17/91 7/24/91	Recorded by	

1:30 Add (38 ft.)(2.35 ft³/ft) = 3 yards to well annulus to bring to 60 feet, then add (33 ft)(0.79 ft³/ft) = 1 yard to casing.
Clean up pump, put washup water down the annulus. Will go top off Bw-27 and cw-150, then return to tag the top of the cement to see if successful. Used a 7-sack sand cement w/ 2% bentonite. Decide to go ahead and tag — TOC at 54.3 feet — ~~50~~ in annulus — So, seems to be working.

2:05 Drive to Bw-27 — top off to ground surface

2:35 Drive to cw-150 and top off.
3:00 Clean up and return to Bw-1. Tag at 54 feet in annulus, and 51 feet in the casing.
4:00 Return to office.

Thursday, July 25, 1991

09:00 Arrive at Bw-1. Mark Pierce and Rick from Layne are present and setting up "chem-grout" (T4R-3I-II) portable cement mixer. Will pump neat cement w/ 4% bentonite into annulus. (~5-6 gals water)
I drive to other wells to evaluate condition.
Bw-2: cement to floor surface — open to top of pedastal about 3" water inside. Fairly clean. Trap door in ceiling open.
Bw-12: cement to top of pedastal (pedastal is lower than in Bw-2). 2 drums present.
Bw-27 cement to ground surface. Area clean.

11:00 Have added 50 sacks and still hasn't come to the surface.
11:20 Used up 60 sacks. Mark calls + orders another 60.

Witnessed & Understood by me,	Date	Invented by	Date
	7/24/91 7/25/91	Recorded by	

Project No.
TITLE Bw-1 Book No. 88

From Page No.

13:00 ~~Begin~~ pumping more cement. Roughly tag cement (too soft for precise tag) at depth of about 20 feet. After adding 30 additional sacks, up to within about 7-8 feet surface.
13:15 Cement reaches top of annulus & flows out the feed pipe. Took 102 bags.
14:15 Finish adding cement on hand - 18 sacks in the casing. Will go pick up more cement and continue.
15:00 Continue pumping - add 6 more sacks and reach top. So - used 126 ~~feet~~ sacks total. Clean up put gear away. Will return in AM for top off. (amount of cement used is reasonable for 18" hole with some extra for void spaces).
16:15 Leave site for day

Friday, July 26, 1991

08:00 Arrive at Bw-1. Mark & Gary from Layne are onsite - have topped off Bw-1 and are cleaning up. I go to DRMO to arrange for disposal of airline pipe.
9:00 Return, guide M & G to Cw-150. Pick up pipe, transport to DRMO. They return to Bw-1 to pick up pump, mixer, etc. I go to Bw-2, close trap door, drive to fire station to return fire hose.
10:00 Return hose - give them 4 hoses - 2 damaged ones - ask them to send me the bill & I give them a business card. I return to office - will return for final inspection & return key later.

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
	7/25/91 7/26/91	Recorded by	

Appendix B

TECHNICAL MEMORANDUM: MCCLELLAN AFB WATER WELL ABANDONMENT PROJECT PUMP REMOVAL AND TELEVISION SURVEY

PREPARED FOR: Captain Fran Slavich, McClellan Point of Contact
Gerald Robbins, McClellan Project Officer

PREPARED BY: Chuck Elliott, CH2M HILL Task Manager

COPIES: Bruce Eades, ALC, PMKSE

DATE: April 18, 1991

SUBJECT: McClellan AFB Water Well Abandonment Project
Well Rehabilitation and Television Survey

PROJECT: SAC28722.07

INTRODUCTION

A technical memorandum describing the removal of pumps from Base Wells BW-1 and BW-2 and the results of a television survey in these wells and Wells BW-27 and CW-150 was submitted to McClellan AFB on March 1, 1991. The technical memorandum also recommended that all the wells be rehabilitated, followed by another television survey in BW-1, BW-2, BW-12, and BW-27. The additional work, accomplished in March and April 1991, is described in this technical memorandum.

CITY WELL 150

The television survey of CW-150 conducted during February 1991 revealed that the casing and screen were in relatively good condition and did not require any rehabilitation. In addition, only a thin film of oil was present on the water surface and did not require bailing. However, an obstruction that partially filled the casing was observed at a depth of 168 feet. Also, sections of small-diameter pipe were found in the well, beginning at a depth of 183 feet and extending to the total depth of the well. Finally, rocks and assorted debris were contacted at a depth of 344 feet and blocked the camera at a depth of 347 feet. According to the City of Sacramento, the total well depth is 372 feet. Thus, the lower 25 feet of the casing was filled with debris.

Layne-Western set up at CW-150 on March 13, 1991, and used a bailer to remove debris from the well. The bailer passed the obstruction at 168 feet without noticeable effect, implying that the obstruction was knocked loose. The crew then used the bailer to capture lengths of pipe and assorted debris from the well. In all, 322 feet of piping

was removed from CW-150. The pipe appears to be air line pipe that must have broken off when the pump was removed from the well in 1990. At the conclusion of work at CW-150, debris had been cleared to a total depth of 370 feet. Thus, only 2 feet of debris remained in the hole.

All equipment used at CW-150 was decontaminated by steam-cleaning at the contractor's staging area on McClellan AFB. Piping removed from the hole is stored within the fence at CW-150 and will be transported to the DRMO facility on base for disposal. Because the casing had previously been shown to be in good condition, no additional television survey was required for CW-150.

BASE WELLS

Work performed in base wells involved first bailing oil floating on the water in BW-1 and BW-12. Next, each well was "scratched" to clean iron bacteria and encrustations from the casing. Finally, each base well was given a television survey to determine whether the cleanup was successful and evaluate the condition of the casing prior to cementing. All equipment was steam-cleaned prior to use at each well. Work on base wells was performed between March 18 and April 3, 1991.

PUMP LUBRICATING OIL

The television survey performed in wells during February 1991 had indicated that about 1 foot of pump lubricating oil floated on the surface of the water in BW-1, BW-2, and BW-12. Only a thin film of oil was observed in BW-27 and CW-150. The pump in BW-27 was removed in 1972, and the well has been idle for nearly 19 years. Any oil potentially present in the well in 1972 has probably decomposed by now. CW-150 was given routine maintenance in 1984, at which time the pump was pulled and overhauled. The pump was removed entirely in 1990. During one of these operations, oil may have been removed from the casing--oil is normally released from the pump and pump column during routine pump operation.

Pumps were removed from BW-1, BW-2, and BW-12 in February 1991. BW-1 and BW-12 have been inactive since 1980, while BW-2 has been inactive since 1979. Each of these wells was observed to contain lubricating oil in the first television survey. However, when BW-2 was bailed during rehabilitation in March 1991, no oil was found. This is reasonable since the depth of water in BW-2 was measured at 109 feet, while the uppermost perforated interval runs from about 100 to 110 feet below the ground surface. (Groundwater levels have declined in the Sacramento area since BW-2 was constructed.) Apparently, any oil originally present has flowed through the perforations into the subsurface as water levels have declined. The lubricating oil is light colored and difficult to distinguish from water on the television survey. A check in BW-27 and CW-150 confirmed the absence of oil in these wells.

A 6-inch-diameter, 10-foot-long bailer was lowered into BW-1 and BW-12 to remove the lubricating oil. On the first pass into the hole, the bailer was completely lowered into the water, so that oil flowed into the top of the bailer. On subsequent passes, the bailer was partially submerged to minimize the intake of water. However, both oil and water were removed from each well. Bailing continued until no additional oil was observed. Each well required two 55-gallon drums to contain the oil/water mixture. These drums are sealed and stored at the well head, and will be disposed of by a petroleum recycler.

WELL CLEANING

Each base well was cleaned by raising and lowering a steel brush along the inside of the casing to dislodge the iron bacteria and encrustation. Each well was slowly brushed from top to bottom in 200-foot strokes until the casing was judged to be clean. The brush was fabricated by drilling closely spaced holes in a 6-foot length of steel pipe. Steel cable was then drawn through the pipe and cut at a length that corresponded to the diameter of the casing. The cable was unraveled so that steel wire formed a rigid brush. A separate brush was prepared for BW-12, BW-27, and BW-1 and BW-2 to accommodate the three differing diameters in these wells. BW-12 was found to contain a 14-inch-diameter casing from the surface to a depth of 140 feet, which then telescoped to 12-inch-diameter casing for the remainder of the hole.

TELEVISION SURVEY

Base wells were given a second television survey following the cleaning of the casing. This survey was performed to determine whether the cleanup was successful and to evaluate the condition of the casing. Previously, the casing was covered with bacterial matting and iron oxide encrustations in each of the base wells. Because of the pressures and stresses imposed on the casing during cementing operations, it was important to examine the casing to locate points of corrosion, cracks, and other zones of potential weakness. Copies of the reports provided by Layne-Western, who performed the survey, are included as Appendix A.

Review of the video tapes revealed that the matting and encrustations were successfully removed from each of the wells. Perforations in the wells were located at approximately the same intervals as described in the original Well Drillers Report, for the wells. Water in the casing tended to be clear adjacent to perforated intervals, where groundwater movement swept suspended particles into casing slots, and cloudy adjacent to blank sections of casing. In general, well casing appeared to be solid and in reasonably good condition.

However, casing in BW-12 was found to be in an advanced state of deterioration. Cracks and holes were found at numerous locations along the casing. In addition to defects noted on the video log (see Appendix A), cracks were noted in the following depth intervals below ground surface: 89-95 feet, 108-111 feet, 336-337 feet, and

367-369 feet. Additional holes were observed at depths of 158, 223, and 235 feet. Many of the slotted perforations appeared to have "ragged" edges, implying that corrosion had occurred.

RECOMMENDATIONS

Each of the wells appears to be ready for decommissioning. BW-1, BW-2, BW-27, and CW-150 seem capable of withstanding the stresses imposed by injecting cement under pressure through a packer. However, because of the weakened conditions of the casing in BW-12, it is recommended that the abandonment approach be modified from that described in the 1991 CH2M HILL report, Well Closure Methods and Procedures.

It is recommended that BW-12 be abandoned in stages using a special fine-grained cement supplied by Halliburton Services. This cement, known as standard fine cement, has particle sizes approximately 10 times smaller than standard cement, and can penetrate openings as narrow as 0.05 millimeters. Because of its small particle size and high surface area, standard fine cement has a high water requirement, resulting in a lightweight slurry of low viscosity. Each lift of cement in BW-12 will be pumped through a tremmie pipe lowered to within 5 feet of the bottom of the well (or top of the previous lift). After pumping, the pipe will be lifted while water is immediately pumped into the top of the well. If the water level can be maintained at the top of the well, then a differential pressure of nearly 50 psi will be available to force the cement into the gravel pack. It should prove easier to maintain a desired head of water in the well as cementing proceeds up the casing and permeable zones are sealed off. This will help to ensure that contaminated water at the water table will not migrate to deeper zones. The use of standard fine cement in BW-12 should not increase the overall cost of well decommissioning above the original cost estimate.

APPENDIX A
TELEVISION SURVEY REPORTS

Layne T.V. CAMERA SURVEY

Date 3/28/91

Customer CH2M Hill   Bw-1

Job No. W41856   Well No. 231   S.W.L. 111'

Location: South of Building 297   Well I.D. 12"

County ______   City ______   State ______

Sec. ______   Twp. ______   Rge. ______

Tape Made Yes ☒ No ☐   Tape File No. 2 copies

Was Well Backflushed? Yes ☒ No ☐

How Long Backflushed? ______

Tape Length In Minutes ______

Brief Well Description Camera zero at top of casing, pad.

(See Well Drawing "Sketch" On Back)

DEPTH	VAN VCR COUNTER	OFFICE VCR COUNTER	DESCRIPTION
0-111			Blank
111			SWL
111-158			Blank
158-174			Millslot Perforation
174-237			Blank
237-241			Millslot Perforation
241-252			Blank
252-257			Millslot Perforation
257-268			Blank
268-275			Millslot Perforation
275-278			Blank
278-296			Millslot
296-315			Blank
315-356			Millslot

Technician ______

LW-275A

Layne T.V. CAMERA SURVEY

Date 3/27/91

Customer CH2M Hill

Job No. 4856 Well No. 252 S.W.L. 110

Location: South of Building 252 BW-2 Well ID 12"

County ______ City ______ State ______

Sec. ______ Twp. ______ Rge. ______

Tape Made Yes ☒ No ☐ Tape File No. 2 copies

Was Well Backflushed? Yes ☒ No ☐

How Long Backflushed? ______

Tape Length In Minutes ______

Brief Well Description ______

(See Well Drawing "Sketch" On Back)

DEPTH	VAN VCR COUNTER	OFFICE VCR COUNTER	DESCRIPTION
0 - 100			Blank
100 - 110			Millslot Perforation above water
110			SWL
110 - 141			Hard to see cloudy water (BLANK)
141 - 158			Millslot
158 - 188			Blank? 158 - 188 water cloudy ?
188 - 197			Millslot should be 180' - 197' water cloudy
197 - 251			BLANK
251 - 291			Millslot Perforation
291			Bottom

Technician ______

LW-275A

Layne **T.V. CAMERA SURVEY**

Date 3/28/91

Customer CH2M Hill

Job No. W4856 Well No. 12 S.W.L.

Location: East of Building 358 Well I.D 14"-139 12"-139-

County City State

Sec. Twp. Rge.

Tape Made Yes ☒ No ☐ Tape File No. 2 copies

Was Well Backflushed? Yes ☒ No ☐

How Long Backflushed?

Tape Length In Minutes

Brief Well Description Camera guilds set for 12" at start of scan.

Hole is very crooked.

Perforation all open.

(See Well Drawing "Sketch" On Back)

DEPTH	VAN VCR COUNTER	OFFICE VCR COUNTER	DESCRIPTION
0-100			Blank
100			SWL
133			Hole in side (2 oclock) 14"
100-162			Blank
162-372			Slot Perforation
175			Hole in Perforation (3 oclock) Large
179			" " " " "
182			
193-200			Casing split open 9 oclock perforated
202			Holes 2 oclock
204			Split Casing (9 oclock)
212			Holes at Seam (3 oclock)
214			Hole in Casing (3 oclock)
218-19			Holes in Casing
332-335			Split
372			Bottom
137-141			Taper to 12" ?

Technician

T.V. CAMERA SURVEY

Layne

Date 4/3/91

Customer Citzn Hill

Job No. W 4355C   Well No. 27   S.W.L. ____

Location:

Well ID 6"

County ____ ____   City ____   State ____

Sec. ____   Twp. ____   Rge. ____ ____

Tape Made   Yes ☒   No ☐   Tape File No. 2 copies

Was Well Backflushed?   Yes ☒   No ☐

How Long Backflushed? 12 Hours

Tape Length In Minutes ____

Brief Well Description ____

(See Well Drawing "Sketch" On Back)

	DEPTH	VAN VCR COUNTER	OFFICE VCR COUNTER	DESCRIPTION
5 [illegible]				
	0 - 26			Blank
	26			checking Screen
	26 - 95			Blank
	95			Sivl
	95 - 180			Blank
185	180 - 190			Perforation millslot
	190 - 212			Blank
210	212 - 222			Perforation millslot
260	222 - 254			Blank, water Cloudy
	254			Bottom

Technician ____

LW-275A

Appendix C

MATERIAL SAFETY DATA SHEETS

MATERIAL SAFETY DATA SHEET
HALLIBURTON SERVICES
DUNCAN, OKLAHOMA 73536

DATE: 04-15-91
REVISED DATE 10-17-90

EMERGENCY TELEPHONE: 405/251-3565 OR 405/251-3569
AFTER HOURS: 405/251-3760

* * * * * * * * * * SECTION I - PRODUCT DESCRIPTION - * * * * * * * * * * * *

HEMICAL CODE: FLOCELE 3/8"   PART NUMBER: 890500710
KG QTY: 25# BAG   APPLICATION: LOSS CIRCULATION ADDITIVE
VICE USED: CEMENTING

* * * * * * * * * SECTION II - COMPONENT INFORMATION - * * * * * * * * * * *

COMPONENT+ + + + + + + + + + +	PERCENT	TLV	PEL
ELLOPHANE	> 60 %	10 MG/M3	15 MG/M3

* * * * * * * * * * * * SECTION III - PHYSICAL DATA - * * * * * * * * * * * * * *

PROPERTY	MEASUREMENT
EARANCE	COLORLESS SOLID, FLAKES
DOR	ODORLESS
CIFIC GRAVITY (H2O=1)	1.440
K DENSITY	15.00 LB/CU.FT.
H	5.5
OLUBILITY IN WATER AT DEG C. GMS/100ML H2O	INSOLUBLE
DEGRADABILITY	SLOWLY
ERCENT VOLATILES	N/A
PORATION RATE(BUTYL ACETATE=1)	N/A
OR DENSITY	N/A
APOR PRESSURE (MMHG)	N/D
OILING POINT(760 MMHG)	N/A
R POINT	N/A
EEZE POINT	N/A
OLUBILITY IN SEAWATER	NOT EVALUATED
TITION COEF (OCTANOL IN WATER)	NOT EVALUATED

* * * * * * * * * * SECTION IV - FIRE AND EXPLOSION DATA - * * * * * * * * * * *

A(704) RATING:
HEALTH 1   FLAMMABILITY 0   REACTIVITY 0   SPECIAL NONE
LASH POINT   N/A
OIGNITION TEMPERATURE   ND F /   ND C
MMABLE LIMITS (OZ. PER CU. FT.)   LOWER   N/D   UPPER   N/D
++

INGUISHING MEDIA:
USE WATER SPRAY, FOAM, DRY CHEMICAL, OR CARBON DIOXIDE.
PECIAL FIRE FIGHTING PROCEDURES:
AVOID CREATING DUST CLOUDS WITH EXTINGUISHERS.
FULL PROTECTIVE CLOTHING AND NIOSH/MSHA APPROVED SELF-CONTAINED BREATHING APPARATUS REQUIRED FOR FIRE FIGHTING PERSONNEL.
NUSUAL FIRE AND EXPLOSION HAZARDS:
INCOMPLETE THERMAL DECOMPOSITION MAY PRODUCE CARBON DIOXIDE AND CARBON MONOXIDE.

[redacted]IFORNIA PROPOSITION 65:
[redacted]DUCT OR PRODUCT COMPONENTS ARE NOT REGULATED UNDER CALIF. PROPOSITION 65.

ARCINOGENIC DETERMINATION:
[redacted]DUCT OR COMPONENTS ARE NOT LISTED AS A POTENTIAL CARCINOGEN
[redacted]ORDING TO : "NTP, IARC, OSHA, OR, ACIGH".

[redacted]DUCT TOXICITY DATA: NOT DETERMINED

RODUCT TLV: 10 MG/M3 (T); 5 MG/M3 (R)

[redacted] ---------------------------- EFFECTS OF EXPOSURE ----------------------------
[redacted]IMARY ROUTES OF EXPOSURE:
INHALATION.
[redacted]:
[redacted]ESSENTIALLY NON-IRRITATING.
KIN:
[redacted]ESSENTIALLY NON-IRRITATING.
[redacted]ALATION:
TREAT AS NUISANCE DUST.
NGESTION:
[redacted] THIS MATERIAL IS OF VERY LOW ACUTE TOXICITY. THERE IS NO EVIDENCE OF ADVERSE EFFECTS FROM AVAILABLE INFORMATION.
HRONIC EFFECTS:
[redacted] NO CHRONIC EFFECTS EXPECTED.
[redacted]ER SYMPTOMS AFFECTED:
A REVIEW OF AVAILABLE DATA DOES NOT IDENTIFY ANY CONDITIONS WORSENED BY EXPOSURE TO THIS PRODUCT.
[redacted] -------------------- EMERGENCY AND FIRST AID PROCEDURES --------------------
UNDER NORMAL CIRCUMSTANCES, NO FIRST AID PROCEDURES WOULD BE REQUIRED.

[redacted] * * * * * * * * * * SECTION VI - REACTIVITY DATA - * * * * * * * * * * * *

TABILITY: STABLE
[redacted]DITIONS TO AVOID:
[redacted] NOT APPLICABLE.
NCOMPATIBILITY (MATERIALS TO AVOID):
STRONG OXIDIZERS.
[redacted]ARDOUS DECOMPOSITION PRODUCTS:
CARBON MONOXIDE AND/OR CARBON DIOXIDE.
AZARD POLYMERIZATION: WON"T OCCUR
[redacted]DITIONS TO AVOID:
[redacted] NOT APPLICABLE.

[redacted] * * * * * * * * * SECTION VII - SPILL OR LEAK PROCEDURES - * * * * * * * * * *

TEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED:
USE PROTECTIVE EQUIPMENT. SWEEP UP AND REMOVE. AVOID CREATING OR INHALING DUST.
[redacted]STE DISPOSAL METHOD:
IF NOT CONTAMINATED, REUSE PRODUCT.
[redacted] GET APPROVAL FROM LANDFILL OPERATOR AND TRANSPORT TO SANITARY LANDFILL.

* * * * * * * * * SECTION VIII - SPECIAL PROTECTION INFORMATION - * * * * * * * *

[redacted]PIRATORY PROTECTION (USE NIOSH/MSHA APPROVED EQUIPMENT):
NOT NORMALLY NECESSARY.
ENTILATION:
[redacted] USE ONLY WITH ADEQUATE VENTILATION. LOCAL EXHAUST VENTILATION IS NOT NORMALLY NEEDED.
PROTECTIVE GLOVES:

YE PROTECTION:
GOGGLES AND/OR FACE SHIELD.
ER PROTECTIVE EQUIPMENT:
NORMAL WORK COVERALLS.

* * * * * * * * * * SECTION IX - SPECIAL PRECAUTIONS - * * * * * * * * * *

RECAUTIONARY LABELING FLOCELE 3/8" 990.500710

CAUTION!
TREAT AS NUISANCE DUST.
FOR PRECAUTIONARY STATEMENTS, REFER TO SECTIONS IV-VIII.
ER HANDLING AND STORAGE CONDITIONS:
STORE IN DRY LOCATION TO PROTECT PRODUCT QUALITY.
AVOID CREATING OR INHALING DUST.
TAINER DISPOSITION:
EMPTY CONTAINER COMPLETELY. DISPOSE OF EMPTY CONTAINER IN SANITARY LANDFILL
BY FIRST OBTAINING LANDFILL OPERATOR'S AUTHORIZATION.

* * * * * * * * * SECTION X - TRANSPORTATION INFORMATION - * * * * * * * * * *

OT SHIPPING DESCRIPTION:
T RESTRICTED

* * * * * * * * * - SECTION XI ENVIRONMENTAL EVALUATION - * * * * * * * * * *

A SUPERFUND(SARA) TITLE III - HAZARD CLASSIFICATION & ASSOCIATED INFORMATION
FIRE: N PRESSURE: N REACTIVE: N ACUTE (IMMEDIATE): Y
CHRONIC (DELAYED): N MIXTURE OR PURE MATERIAL: MIX

EPA - CERCLA/SUPERFUND, 40 CFR 302 (REPORTABLE SPILL QUANTITY)
N/A

EPA - SARA TITLE III, CFR 355 (EXTREMELY HAZARDOUS SUBSTANCES)
PRODUCT CONTAINS NO EXTREMELY HAZARDOUS COMPONENTS

EPA - SARA TITLE III, 40 CFR 372 (LIST OF TOXIC CHEMICALS)
CHEMICAL CONTAINS NO TOXIC INGREDIENTS

COMPONENTS LISTED ON FOLLOWING CHEMICAL INVENTORIES
TSCA YES CEPA NE EEC YES ACOIN YES NPR YES DRSM YES

EPA - RCRA (HAZARDOUS WASTE), 40 CFR 261

IF PRODUCT BECOMES A WASTE, IT DOES NOT MEET THE CRITERIA OF A
HAZARDOUS WASTE

* *

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EQUIREMENTS OF ALL APPLICABLE LAWS AND REGULATIONS REGARDING ITS USE. THIS

ROPERTY. ANY OTHER USE OF THIS INFORMATION IS EXPRESSLY PROHIBITED.
ERNMENT REGULATIONS DEPARTMENT, HALLIBURTON SERVICES.

MATERIAL SAFETY DATA SHEET DATE: 04 15-91
HALLIBURTON SERVICES REVISED DATE 08-06-90
DUNCAN, OKLAHOMA 73536

EMERGENCY TELEPHONE: 405/251-3565 OR 405/251-3569
AFTER HOURS: 405/251-3760

* * * * * * * * * * SECTION I - PRODUCT DESCRIPTION - * * * * * * * * * * * *

HEMICAL CODE: CEMENT, STANDARD FINE PART NUMBER: 516004840
KG QTY: SACK APPLICATION: CEMENT
VICE USED: CEMENTING

* * * * * * * * * * SECTION II - COMPONENT INFORMATION - * * * * * * * * * * *

COMPONENT+ + + + + + + + + +	PERCENT	TLV	PEL
RTLAND CEMENT	> 60 %	10 MG/M3	15 MG/M3
ICA, CRYSTALLINE--QUARTZ	< 3 %	0.1 MG/M3	0.1 MG/M3

* * * * * * * * * * * SECTION III - PHYSICAL DATA - * * * * * * * * * * * * * *

PROPERTY	MEASUREMENT
PPEARANCE	GRAY SOLID, POWDER
R	ODORLESS
CIFIC GRAVITY (H20=1)	3.150
LK DENSITY	94.00 LB/CU.FT.
H	12.4
UBILITY IN WATER AT DEG C, GMS/100ML H20	.1-1.0
IODEGRADABILITY	N/A
RCENT VOLATILES	0
PORATION RATE(BUTYL ACETATE=1)	N/A
APOR DENSITY	N/A
POR PRESSURE (MMHG)	N/A
LING POINT(760 MMHG)	N/A
UR POINT	N/A
REEZE POINT	N/A
UBILITY IN SEAWATER	NOT EVALUATED
RTITION COEF (OCTANOL IN WATER)	NOT EVALUATED

* * * * * * * * * * SECTION IV - FIRE AND EXPLOSION DATA - * * * * * * * * * * *

FPA(704) RATING:
HEALTH 1 FLAMMABILITY 0 REACTIVITY 0 SPECIAL NONE
SH POINT NONE
TOIGNITION TEMPERATURE ND F / ND C
LAMMABLE LIMITS (OZ. PER CU. FT.) LOWER N/D UPPER N/D
++
TINGUISHING MEDIA:
NONCOMBUSTIBLE
ECIAL FIRE FIGHTING PROCEDURES:
NOT APPLICABLE.
NUSUAL FIRE AND EXPLOSION HAZARDS:
NO FIRE HAZARD.
NOT APPLICABLE.

* * * * * * * * * * SECTION V - HEALTH HAZARD DATA * * * * * * * * * * *

ALIFORNIA PROPOSITION 65:
DUCT OR PRODUCT COMPONENTS ARE REGULATED UNDER CALIF. PROPOSITION 65.

ARCINOGENIC DETERMINATION:
RODUCT OR COMPONENTS ARE LISTED AS A POTENTIAL CARCINOGEN
ORDING TO : IARC

RODUCT TOXICITY DATA: NOT DETERMINED

DUCT TLV: 10 MG/M3 (T) 5 MG/M3 (R)

---------- EFFECTS OF EXPOSURE ----------

TES OF EXPOSURE:
EYE OR SKIN CONTACT, INHALATION.

YE:
DUST MAY CAUSE MODERATE TO SEVERE EYE IRRITATION WITH CORNEAL INJURY THAT MAY BE SLOW TO HEAL.

KIN:
CEMENT DUST CAN BE IRRITATING TO SKIN. WET CEMENT CAN DRY THE SKIN AND CAUSE ALKALI BURNS. SENSITIVE INDIVIDUALS MAY DEVELOP ALLERGIC DERMATITIS.

NHALATION:
MAY BE IRRITATING.
TREAT AS NUISANCE DUST.

RONIC EFFECTS:
CRYSTALLINE SILICA IS NOT ON THE NTP OR OSHA CARCINOGEN LIST. IARC HAS DETERMINED THERE IS SUFFICIENT EVIDENCE FOR CARCINOGENICITY OF CRYSTALLINE SILICA TO EXPERIMENTAL ANIMALS AND LIMITED EVIDENCE TO HUMANS. "LIMITED EVIDENCE" MEANS POSSIBLE RELATIONSHIP, BUT OTHER FACTORS CANNOT BE EXCLUDED. CONTAINS TRACE AMOUNTS OF ARSENIC, A CHEMICAL KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER. EXPOSURE TO ARSENIC SHOULD NOT EXCEED THE FEDERAL OSHA PEL UNLESS USED IN A MANNER THAT PRODUCES EXTREMELY HEAVY AIR-BORNE CONCENTRATIONS OF PRODUCT AT LEVELS WELL ABOVE THE ALLOWABLE LIMITS.

ESE SYMPTOMS AFFECTED:
BECAUSE OF ITS IRRITATING PROPERTIES, THIS MATERIAL MAY AGGRAVATE AN EXISTING DERMATITIS.

---------- EMERGENCY AND FIRST AID PROCEDURES ----------

E:
IMMEDIATELY FLUSH EYES WITH PLENTY OF WATER FOR AT LEAST 15 MINUTES. IF IRRITATION PERSISTS, SEEK PROMPT MEDICAL ATTENTION.

IN:
PROMPTLY WASH SKIN WITH SOAP AND WATER. WASH CLOTHING BEFORE REUSE.

NHALATION:
REMOVE TO FRESH AIR. IF IRRITATION PERSISTS, SEEK MEDICAL ATTENTION.

ESTION:
DO NOT INDUCE VOMITING! IN GENERAL, NO TREATMENT IS NECESSARY UNLESS LARGE QUANTITIES ARE INGESTED. HOWEVER, MEDICAL ADVICE SHOULD BE OBTAINED.

* * * * * * * * * * * SECTION VI - REACTIVITY DATA - * * * * * * * * * * * *

ABILITY: STABLE
ONDITIONS TO AVOID:
STORE IN A DRY LOCATION.
COMPATIBILITY (MATERIALS TO AVOID):
NONE KNOWN.
AZARDOUS DECOMPOSITION PRODUCTS:
NONE KNOWN.
ZARD POLYMERIZATION: WON'T OCCUR
ONDITIONS TO AVOID:
NOT APPLICABLE.

* * * * * * * * * SECTION VII - SPILL OR LEAK PROCEDURES - * * * * * * * * *

USE PROTECTIVE EQUIPMENT. SWEEP UP AND REMOVE. AVOID CREATING OR INHALING DUST.

TE DISPOSAL METHOD:
IF NOT CONTAMINATED, REUSE PRODUCT.
GET APPROVAL FROM LANDFILL OPERATOR AND TRANSPORT TO SANITARY LANDFILL.

* * * * * * * SECTION VIII - SPECIAL PROTECTION INFORMATION - * * * * * * *

PIRATORY PROTECTION (USE NIOSH/MSHA APPROVED EQUIPMENT):
TOXIC DUST/MIST RESPIRATOR.
ENTILATION:
USE ONLY WITH ADEQUATE VENTILATION.
TECTIVE GLOVES:
NORMAL WORK GLOVES.
YE PROTECTION:
DUST PROOF GOGGLES.
ER PROTECTIVE EQUIPMENT:
NORMAL WORK COVERALLS.

* * * * * * * * * * SECTION IX - SPECIAL PRECAUTIONS - * * * * * * * * * *

CAUTIONARY LABELING CEMENT, STANDARD FINE 516.004840

WARNING!
CONTAINS A SMALL AMOUNT OF CRYSTALLINE SILICA, REPEATED OR PROLONGED INHALATION OF DUST MAY CAUSE A DELAYED RESPIRATORY ILLNESS (SILICOSIS). THE INTERNATIONAL AGENCY FOR RESEARCH ON CANCER (IARC) HAS DETERMINED THERE IS LIMITED EVIDENCE OF THE CARCINOGENICITY OF CRYSTALLINE SILICA.
MAY CAUSE EYE AND SKIN IRRITATION.
MAY CAUSE SKIN BURNS IF CEMENT IS WET OR WITH CONFINED INTIMATE CONTACT.
FOR PRECAUTIONARY STATEMENTS, REFER TO SECTIONS IV-VIII.
THER HANDLING AND STORAGE CONDITIONS:
STORE IN DRY LOCATION TO PROTECT PRODUCT QUALITY.
AVOID CREATING OR INHALING DUST.
AVOID CONTACT WITH SKIN, EYES AND CLOTHING.
TAINER DISPOSITION:
EMPTY CONTAINER COMPLETELY. DISPOSE OF EMPTY CONTAINER IN SANITARY LANDFILL BY FIRST OBTAINING LANDFILL OPERATOR'S AUTHORIZATION.

* * * * * * * * SECTION X - TRANSPORTATION INFORMATION - * * * * * * * * *

OT SHIPPING DESCRIPTION:
RESTRICTED

* * * * * * * * * - SECTION XI ENVIRONMENTAL EVALUATION - * * * * * * * * * *

SUPERFUND(SARA) TITLE III - HAZARD CLASSIFICATION & ASSOCIATED INFORMATION
FIRE: N PRESSURE: N REACTIVE: N ACUTE (IMMEDIATE): Y
CHRONIC (DELAYED): N MIXTURE OR PURE MATERIAL: PURE

EPA - CERCLA/SUPERFUND, 40 CFR 302 (REPORTABLE SPILL QUANTITY)
N/A

EPA - SARA TITLE III, CFR 355 (EXTREMELY HAZARDOUS SUBSTANCES)
PRODUCT CONTAINS NO EXTREMELY HAZARDOUS COMPONENTS

EPA - SARA TITLE III, 40 CFR 372 (LIST OF TOXIC CHEMICALS)
CHEMICAL CONTAINS NO TOXIC INGREDIENTS

COMPONENTS LISTED ON FOLLOWING CHEMICAL INVENTORIES
TSCA YES CEPA NE EEC YES ACOIN YES NPR YES DRSM YES

IF PRODUCT BECOMES A WASTE, IT DOES NOT MEET THE CRITERIA OF A
HAZARDOUS WASTE

* *

HE INFORMATION WHICH IS CONTAINED IN THIS DOCUMENT IS BASED UPON AVAILABLE
TA AND BELIEVED TO BE CORRECT. HOWEVER, AS SUCH AS IT HAS BEEN OBTAINED FROM
RIOUS SOURCES, INCLUDING THE MANUFACTURER AND INDEPENDENT LABORATORIES, IT IS
IVEN WITHOUT WARRANTY OR REPRESENTATION THAT IT IS COMPLETE, ACCURATE AND CAN
E RELIED UPON. HALLIBURTON HAS NOT ATTEMPTED TO CONCEAL IN ANY WAY THE
LETERIOUS ASPECTS OF THE PRODUCT LISTED HEREIN, BUT MAKES NO WARRANTY AS TO
CH. FURTHER, AS HALLIBURTON CANNOT ANTICIPATE NOR CONTROL THE MANY
ITUATIONS IN WHICH THE LISTED PRODUCT OR THIS INFORMATION MAY BE USED BY OUR
STOMER, THERE IS NO GUARANTEE THAT THE HEALTH AND SAFETY PRECAUTIONS
GGESTED WILL BE PROPER UNDER ALL CONDITIONS. IT IS THE SOLE RESPONSIBILITY
F EACH USER OF THE LISTED PRODUCT TO DETERMINE AND COMPLY WITH THE
QUIREMENTS OF ALL APPLICABLE LAWS AND REGULATIONS REGARDING ITS USE. THIS
FORMATION IS GIVEN SOLELY FOR THE PURPOSES OF SAFETY TO PERSONS AND
ROPERTY. ANY OTHER USE OF THIS INFORMATION IS EXPRESSLY PROHIBITED.
OVERNMENT REGULATIONS DEPARTMENT, HALLIBURTON SERVICES.

MATERIAL SAFETY DATA SHEET DATE: 07-16-91
HALLIBURTON SERVICES REVISED DATE 06-27-91
DUNCAN, OKLAHOMA 73536

EMERGENCY TELEPHONE: 405/251-3565 OR 405/251-3569
AFTER HOURS: 405/251-3760

* * * * * * * * * SECTION I - PRODUCT DESCRIPTION - * * * * * * * * * * *

H MICAL CODE: CAL-SEAL (EA-2), ADDITIVE PART NUMBER: 890501310
K QTY: 100# M/W PAPER BAG APPLICATION: ACCELERATOR, TEMPORARY PLUGS
ERVICE USED: CEMENTING

* * * * * * * * SECTION II - COMPONENT INFORMATION - * * * * * * * * * *

COMPONENT+ + + + + + + + + + +	PERCENT	TLV	PEL
A CIUM SULFATE HEMIHYDRATE	> 60 %	10 MG/M3	15 MG/M3

* * * * * * * * * * * SECTION III - PHYSICAL DATA - * * * * * * * * * * * * *

PROPERTY	MEASUREMENT
PEARANCE	WHITE SOLID, POWDER
O R	ODORLESS
P CIFIC GRAVITY (H2O=1)	2.700
ULK DENSITY	75.00 LB/CU.FT.
H	10.4
O UBILITY IN WATER AT O DEG C. GMS/100ML H2O	0.2%
IODEGRADABILITY	N/D
E CENT VOLATILES	N/A
VAPORATION RATE(BUTYL ACETATE=1)	N/A
APOR DENSITY	N/A
A OR PRESSURE (MMHG)	N/D
O LING POINT(760 MMHG)	N/A
OUR POINT	N/A
R EZE POINT	N/A
O UBILITY IN SEAWATER	NOT EVALUATED
ARTITION COEF (OCTANOL IN WATER)	NOT EVALUATED

* * * * * * * * SECTION IV - FIRE AND EXPLOSION DATA - * * * * * * * * * * *

FPA(704) RATING:
HEALTH 0 FLAMMABILITY 0 REACTIVITY 0 SPECIAL NONE
L SH POINT N/A
UTOIGNITION TEMPERATURE NO F / ND C
LAMMABLE LIMITS (OZ. PER CU. FT.) LOWER N/D UPPER N/D
++
XTINGUISHING MEDIA:
USE MEDIA APPROPRIATE FOR SURROUNDING MATERIALS.
P CIAL FIRE FIGHTING PROCEDURES:
NOT APPLICABLE.
NUSUAL FIRE AND EXPLOSION HAZARDS:
NOT APPLICABLE.

* * * * * * * * * * * SECTION V - HEALTH HAZARD DATA - * * * * * * * * * * *

A IFORNIA PROPOSITION 65:
R ODUCT OR PRODUCT COMPONENTS ARE NOT REGULATED UNDER CALIF. PROPOSITION 65.

ACINOGENIC DETERMINATION:
RODUCT OR COMPONENTS ARE NOT LISTED AS A POTENTIAL CARCINOGEN
CORDING TO : "NTP, IARC, OSHA, OR, ACIGH".

RODUCT TOXICITY DATA: TOX IHL-HMN TCLO: 194000 MG/M3/10Y-I
AQU TLM96.OVER 1000 PPM

RODUCT TLV: NUISANCE: 10 MG/M3(T)

---------- EFFECTS OF EXPOSURE ----------

TES OF EXPOSURE:
EYE OR SKIN CONTACT, INHALATION.
Y :
MAY BE IRRITATING.
KIN:
MAY CAUSE MILD ALLERGIC SKIN REACTION IN SUSCEPTIBLE INDIVIDUALS.
PROLONGED OR REPEATED SKIN CONTACT MAY CAUSE SEVERE IRRITATION OR BURNS
ESPECIALLY IF SKIN IS MOIST OR IF MATERIAL IS CONFINED.
NHALATION:
MAY BE IRRITATING.
N ESTION:
NO DATA AVAILABLE
H ONIC EFFECTS:
NO CHRONIC EFFECTS EXPECTED.
THER SYMPTOMS AFFECTED:
A REVIEW OF AVAILABLE DATA DOES NOT IDENTIFY ANY CONDITIONS WORSENED BY
EXPOSURE TO THIS PRODUCT.

---------- EMERGENCY AND FIRST AID PROCEDURES ----------

YE:
IMMEDIATELY FLUSH EYES WITH PLENTY OF WATER FOR AT LEAST 15 MINUTES. IF
IRRITATION PERSISTS, SEEK PROMPT MEDICAL ATTENTION.
KIN:
PROMPTLY WASH SKIN WITH SOAP AND WATER. WASH CLOTHING BEFORE REUSE.
N ALATION:
REMOVE TO FRESH AIR. IF IRRITATION PERSISTS, SEEK MEDICAL ATTENTION.
NGESTION:
DO NOT INDUCE VOMITING! IN GENERAL, NO TREATMENT IS NECESSARY UNLESS LARGE
QUANTITIES ARE INGESTED. HOWEVER, MEDICAL ADVICE SHOULD BE OBTAINED.

* * * * * * * * * * SECTION VI - REACTIVITY DATA - * * * * * * * * * * * * *

TABILITY: STABLE
ONDITIONS TO AVOID:
NOT APPLICABLE.
N OMPATIBILITY (MATERIALS TO AVOID):
NONE KNOWN.
A ARD POLYMERIZATION: WON"T OCCUR
C DITIONS TO AVOID:
NOT APPLICABLE.

* * * * * * * * SECTION VII - SPILL OR LEAK PROCEDURES - * * * * * * * * *

TEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED:
USE PROTECTIVE EQUIPMENT. SWEEP UP AND REMOVE. AVOID CREATING OR INHALING
DUST.
ASTE DISPOSAL METHOD:
IF NOT CONTAMINATED, REUSE PRODUCT.
ET APPROVAL FROM LANDFILL OPERATOR AND TRANSPORT TO SANITARY LANDFILL.

* * * * * * * * SECTION VIII - SPECIAL PROTECTION INFORMATION - * * * * * * * *

SPIRATORY PROTECTION (USE NIOSH/MSHA APPROVED EQUIPMENT):

NOT NORMALLY NECESSARY.
TOXIC DUST/MIST RESPIRATOR.
ENTILATION:
USE ONLY WITH ADEQUATE VENTILATION.
TECTIVE GLOVES:
NORMAL WORK GLOVES.
YE PROTECTION:
GOGGLES AND/OR FACE SHIELD.
ER PROTECTIVE EQUIPMENT:
NORMAL WORK COVERALLS.

* * * * * * * * * * SECTION IX - SPECIAL PRECAUTIONS - * * * * * * * * * *

ECAUTIONARY LABELING CAL-SEAL (EA-2), ADDITIVE 890.501310

CAUTION!
IRRITATING TO THE EYES, SKIN AND RESPIRATORY SYSTEM.
PROLONGED OR REPEATED SKIN CONTACT MAY CAUSE SEVERE IRRITATION OR BURNS
ESPECIALLY IF SKIN IS MOIST OR IF MATERIAL IS CONFINED.
MAY CAUSE ALLERGIC SKIN REACTION IN SUSCEPTIBLE INDIVIDUALS.
FOR PRECAUTIONARY STATEMENTS, REFER TO SECTIONS IV-VIII.
ER HANDLING AND STORAGE CONDITIONS:
STORE IN DRY LOCATION TO PROTECT PRODUCT QUALITY.
AVOID CREATING OR INHALING DUST.
AVOID CONTACT WITH SKIN, EYES AND CLOTHING.
TAINER DISPOSITION:
EMPTY CONTAINER COMPLETELY. DISPOSE OF EMPTY CONTAINER IN SANITARY LANDFILL
BY FIRST OBTAINING LANDFILL OPERATOR'S AUTHORIZATION.

* * * * * * * * * * SECTION X - TRANSPORTATION INFORMATION - * * * * * * * * * *

SHIPPING DESCRIPTION:
T RESTRICTED

* * * * * * * - SECTION XI ENVIRONMENTAL EVALUATION - * * * * * * * * * *

PA SUPERFUND(SARA) TITLE III - HAZARD CLASSIFICATION & ASSOCIATED INFORMATION
FIRE: N PRESSURE: N REACTIVE: N ACUTE (IMMEDIATE): Y
CHRONIC (DELAYED): N MIXTURE OR PURE MATERIAL: MIX

EPA - CERCLA/SUPERFUND, 40 CFR 302 (REPORTABLE SPILL QUANTITY)
N/A

. EPA - SARA TITLE III, CFR 355 (EXTREMELY HAZARDOUS SUBSTANCES)
PRODUCT CONTAINS NO EXTREMELY HAZARDOUS COMPONENTS

. EPA - SARA TITLE III, 40 CFR 372 (LIST OF TOXIC CHEMICALS)
CHEMICAL CONTAINS NO TOXIC INGREDIENTS

. COMPONENTS LISTED ON FOLLOWING CHEMICAL INVENTORIES
TSCA YES CEPA NE EEC YES ACOIN YES NPR NE DRSM NE

EPA - RCRA (HAZARDOUS WASTE), 40 CFR 261

IF PRODUCT BECOMES A WASTE, IT DOES NOT MEET THE CRITERIA OF A
HAZARDOUS WASTE

* *

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UGGESTED WILL BE PROPER UNDER ALL CONDITIONS. IT IS THE SOLE RESPONSIBILITY
EACH USER OF THE LISTED PRODUCT TO DETERMINE AND COMPLY WITH THE
EQUIREMENTS OF ALL APPLICABLE LAWS AND REGULATIONS REGARDING ITS USE. THIS
NFORMATION IS GIVEN SOLELY FOR THE PURPOSES OF SAFETY TO PERSONS AND
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ERNMENT REGULATIONS DEPARTMENT, HALLIBURTON SERVICES.

Appendix D

HALLIBURTON RESEARCH

LOS ANGELES DIVISION LABORATORY

HALLIBURTON SERVICES

OXNARD, CALIFORNIA

LABORATORY REPORT

No. CRZ-C99-0354-091787

Date September 16, 1987

To Mr. Jerry Evanoff
District Engineer
Halliburton Services
Rio Vista, CA

We give below results of our examination of several cement slurries and flow characteristics through perforations and a gravelpack.

Submitted by

Marked

Well:	Several water wells	Lease:	N/A
Depth:	800-1000'	Field:	Salinas Basin
Temperature:	~90°F	County:	Monterey
Formation:	N/A	State:	California

Purpose

The slurries were submitted for evaluation in water well abandonments and their respective efficiencies.

Comments

The data in this report can be found in Lab Notebook LA022, page 54. The lab data obtained suggests that the sand/cement slurrics currently used in the modeled water well abandonments do not cement the gravelpack but only the casing. To obtain a complete abandonment (i.e., cementing both casing and gravelpack to the formation) slurries without sand should be tried.

Discussion

Introduction

A typical waterwell in the Salinas area is completed as shown in Figure 1. The wells are produced for a finite period and then abandoned. Possible reasons for abandoning a waterwell are ground water contamination and salt water encroachment.

The current abandonment technique involves pumping or dumping either a seven part or nine part sand/cement slurry down the casing. This continues until cement is obtained at the surface. The problem noted recently has been that crossflow in abandoned wells between salt water zones and fresh water zones is suspected of contaminating surrounding wells and other fresh water zones. This report examines both currently used abandonment slurries and alternate slurries for these abandonments.

The lab testing was broken into three different phases. These phases were chosen to break the abandonment process into its separate parts. The phases are: 1) pumping the slurry down the casing, 2) slurry flow through the perforations or slots and 3) slurry flow through the gravel pack to the formation for a complete seal. The slurries evaluated during the testing are given in Table 1. They consist of two currently used sand/cement slurries and three possible replacement slurries. Table 2 briefly describes the actual flow tests performed.

Perforation Tests

The apparatus used for the perforation flow tests is shown in Figure 2. The perforation size of one-tenth of an inch (0.100") was chosen to model the slots used in the actual wells which are 0.100 inches. The results are given in Table 3. The only slurries which failed were the sand/cement slurries. A plot of sieve opening versus cumulative weight retained for the sands used in the sand/cement slurry explains why these slurries failed (Figure 3). The D_{50}, or the diameter which 50% of the sand is retained on a sieve, was 0.0325" for the Logan sand and 0.025" for the Hollister sand. The D_{50}'s of both sands falls into the optimum plugging size range for an opening of 0.100". Optimum plugging has been shown to occur when the particle size diameter is approximately 1/4 to 1/3 the opening diameter (see References 1-3). For a 0.100" opening, the optimum plugging diameter range of 0.025" to 0.033" would be calculated. Unfortunately, this range is almost exactly the D_{50} value for both the Logan and Hollister sand.

Gravelpack Tests

The gravelpack flow tests were performed on the apparatus shown in Figure 4. The results are listed in Table 3. Every slurry which passed the perforation test (Slurries 2, 3 and 4) also passed the gravelpack tests. Again, Slurries 2, 3 and 4 passed the gravelpack tests.

Discussion

Perforation/Gravelpack Tests

The perforation/gravelpack tests were performed with the apparatus shown in Figure 5. The results are listed in Table 3. Slurries 2, 3 and 4 passed the test both with and without a 25% w/w contamination of formation sand in the gravelpack. The only parameter which changed was the pressure required to push the slurry through the gravelpack. As expected, the slurry with the lowest viscosity, Slurry 4, was the easiest to push through the perforation and gravelpack.

References

Saucier, R. J.: "Gravel Pack Design Considerations," paper SPE 4030 presented at SPE-AIME 47th Annual Fall Meeting, San Antonio, Oct. 8-11, 1972

Coberly, C. J.: "Selection of Screen Openings for Unconsolidated Sands," Drill. and Prod. Prac. API (1937)

Coberly, C. J., and Wagner, E. M.: "Some Considerations in the Selection and Installation of Gravel Packs for Oil Wells," Petroleum Technology, AIME Tech. Pub. No. 960 (Aug., 1938).

Figure 1. General Well Schematic for Typical Water Well Completion

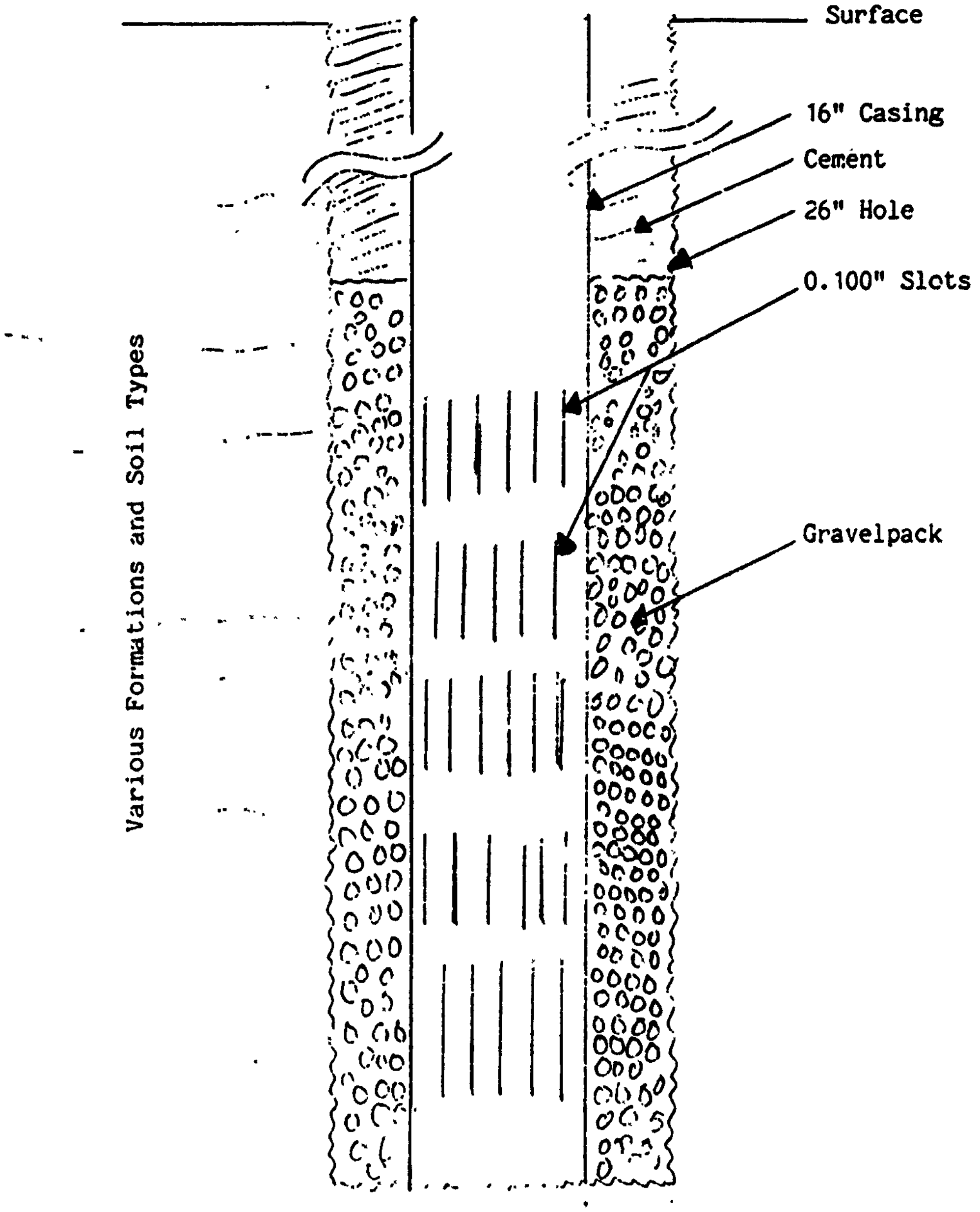
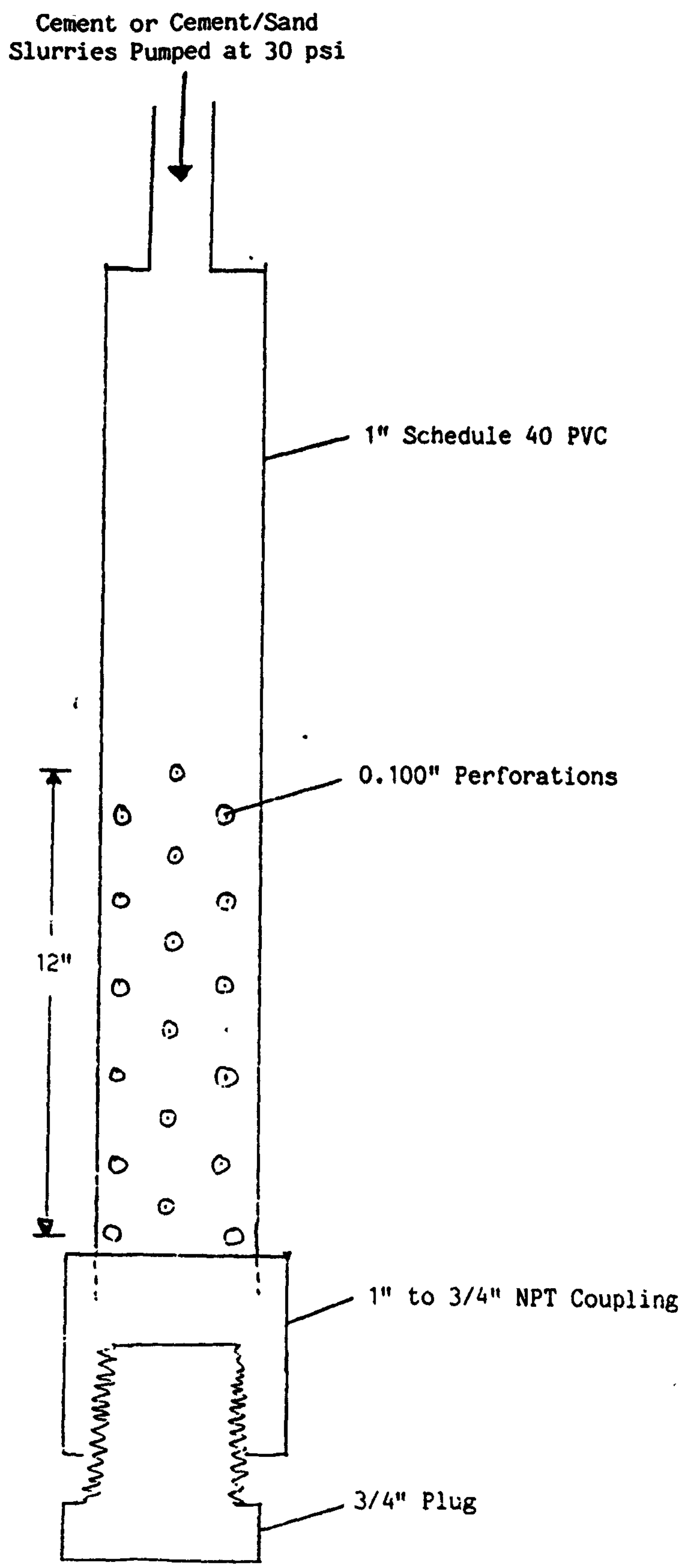


Figure 2. Perforation Flow Test



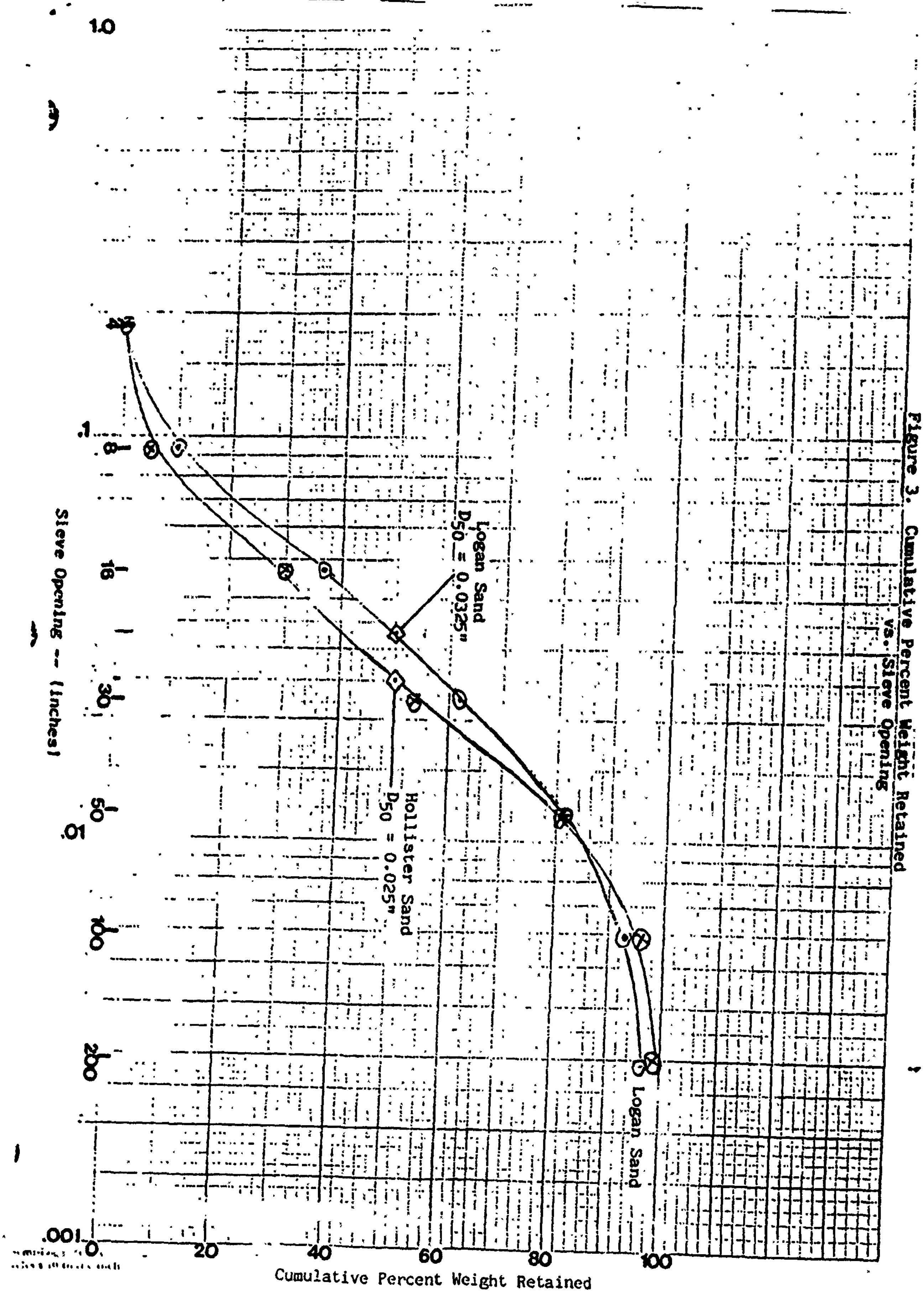


Figure 3. Cumulative Percent Weight Retained vs. Sieve Opening

Figure 4. Gravelpack Flow Test

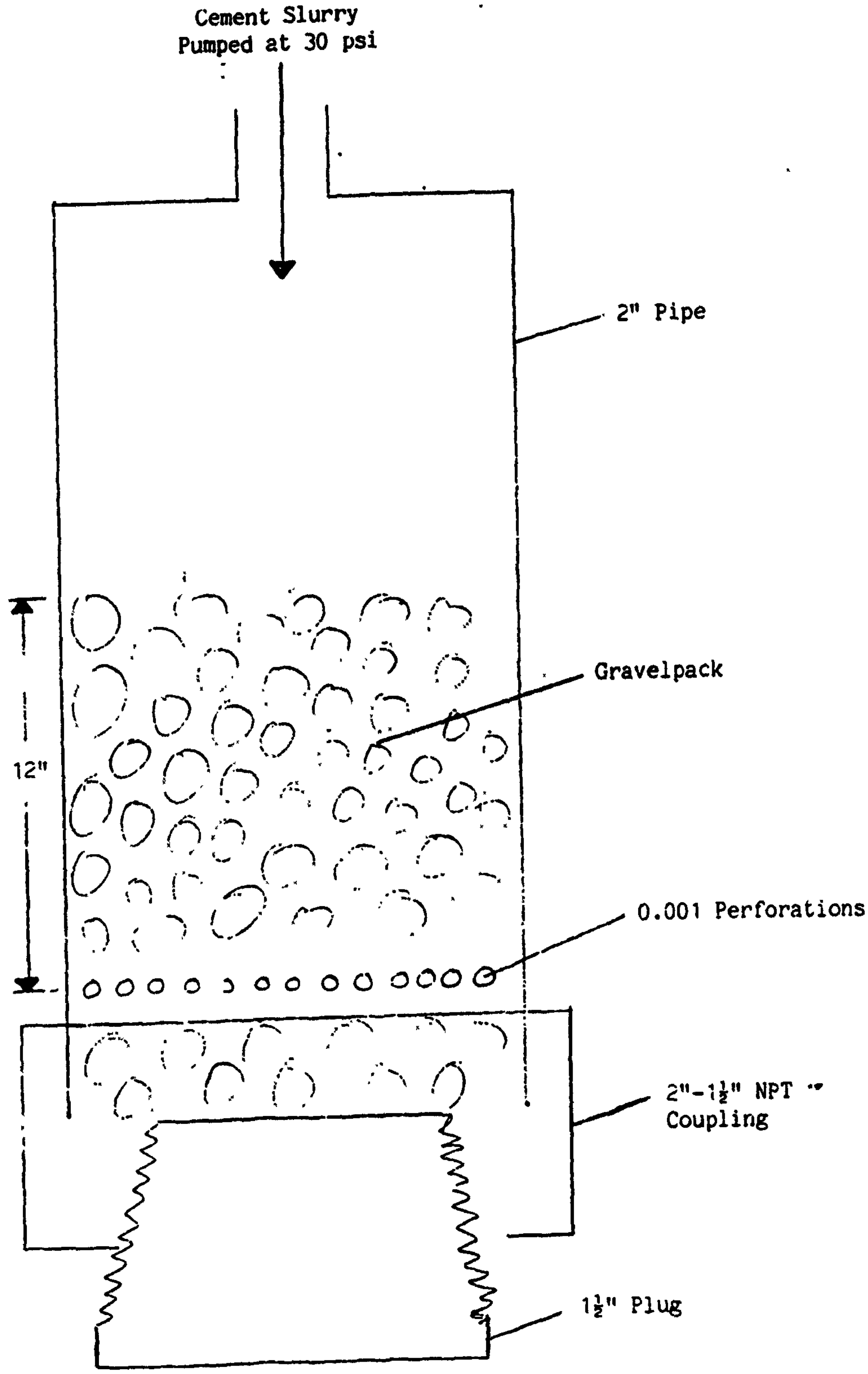


Figure 5. Perforation - Gravelpack Flow Tests

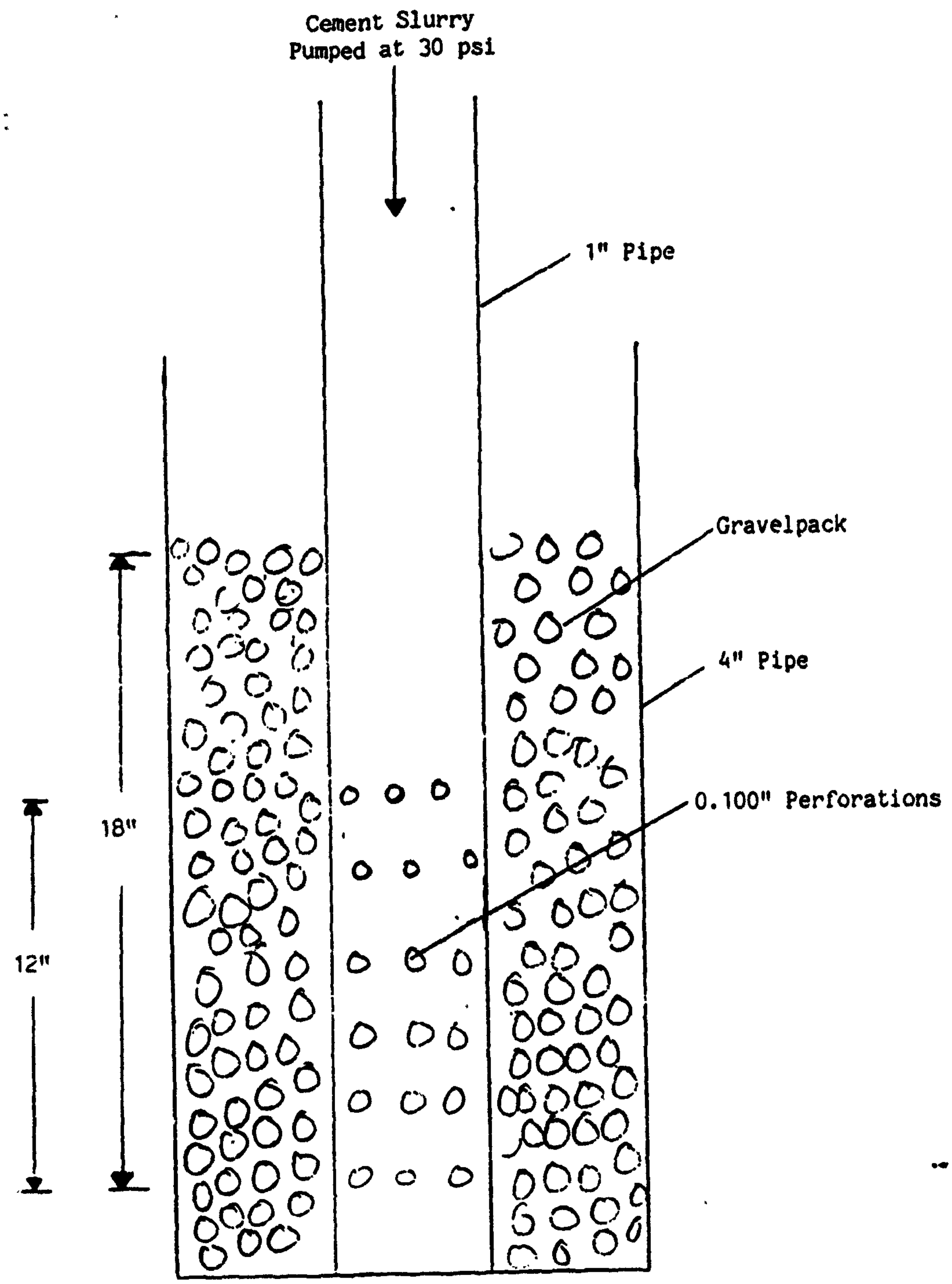


Table 1. Slurry Composition of Cements Evaluated

Slurry No.	Slurry Composition
1A	Premium Cement + 7 yds. of Sand per 1 yd. Cement
1B	Premium Cement + 9 yds. of Sand per 1 yd. Cement
2	50:50 Pozmix A Cement + 2% Gel (14.15 ppg)
3	Premium Cement (15.8 ppg)
4	Premium Cement + 1% CFR-3 (15.8 ppg) "Dispersed or Thinned Slurry"

Table 2. Test Descriptions

Test No.	Test Description
1	The slurry was pumped under 30 psi pressure (when required) through the perforations (0.100") in the one inch (1") pipe (Figure 2). A pass indicates the slurry showed no plugging tendencies and a fail indicates the slurry plugged off the perforations.
2	The slurry was pumped under 30 psi pressure (when required) through the gravelpack column (Figure 4). A pass indicated the slurry did not plug the sandpack and a fail indicated the slurry plugged the gravelpack.
3	The slurry was pumped through the perforations and out into the gravelpack (Figure 5) under 30 psi pressure (when required). A pass indicated the slurry successfully went through both the perforations and gravelpack. A fail indicated that the slurry plugged off at either the perforation or the gravelpack.
4	Similar to Test 3, except formation material at 25% w/w was used to contaminate the gravelpack.

Table 3. Test Results of Various Flow Tests

Test No.	Slurry No.	Pass/Fail	Notes
1	1A	Fail	The slurry plugged off the perforations immediately. The fluid leaked from the perforations at a very low rate was clear water characteristic of fluid loss test filtrate material.
1	1B	Fail	Similar to Slurry 1A, Test 1 results.
1	2	Pass	A pressure of 10 psi was required to push the slurry out the perforations. No plugging was detected (all perfs open at end of test).
1	3	Pass	No pressure was required for the slurry to flow through the perforations.
1	4	Pass	Similar to Slurry 3, Test 1.
2	2	Pass	A pressure of 10 psi was required to push Slurry 2 through the gravelpack. No plugging detected.
2	3	Pass	The slurry flowed through the gravelpack with 5 psi pressure required. No plugging was detected.
2	4	Pass	The slurry flowed through the gravelpack with no pressure required.
3	2	Pass	A pressure of 10 psi was required to move the slurry through the perforations and the gravelpack. No plugging was detected.
3	3	Pass	No plugging was detected. A pressure of 5 psi was required to push the slurry through the perforations and gravelpack.
3	4	Pass	No plugging was detected and no pressure was required to displace the slurry.

Table 3. Test Results of Various Flow Tests (Cont.)

Test No.	Slurry No.	Pass/Fail	Notes
4	2	Pass	A pressure of 30+ psi was required to push the slurry through the perforations and contaminated gravelpack.
4	3	Pass	A pressure of 10 psi was required to push the slurry through the perforations and the contaminated gravelpack.
4	4	Pass	Hydrostatic pressure displaced the slurry through the perforations and the contaminated gravelpack.

cc: Mr. M. Glass( )ck/Mr. J. Diller
Mr. D. Smith
Mr. M. Melton
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Respectfully submitted,

Laboratory Analyst

Almond / Rader

HALLIBURTON SERVICES

By Steve Almond

Steve Almond

Appendix E

RESPONSE TO AGENCY COMMENTS

SUBJECT: McClellan AFB Water Well Abandonment Project
Draft Informational Field Report
Delivery Order 5007

PROJECT: SAC28722.07

REVIEWER: Will Rowe, California Environmental Protection Agency, Department of Toxic Substances Control, Technical and Support Services Branch

DATE: November 26, 1991

Comment: General--The Report describes the decommissioning of five (5) production wells on or next to McClellan AFB. Perforated zones and lift intervals are concisely depicted in Report figures.

(No response)

Comment: Well Casing Perforations Installed for Decommissioning--The Report does not document the exact method of perforating well casings for decommissioning. Specifically, the Report does not address well casings being knifed and grouted in stages at designated intervals. This is a deviation from the adopted Procedures document which states on Page V of the Executive Summary that "...Upon reaching intervals of casing that are not perforated, abandonment will stop while a downhole perforator is lowered into the well."

Rationale needs to be provided as to why deviation from prescribed decommissioning methods was used, especially without concurrence from Department staff.

Response: Well BW-1 was the only well where the casing was perforated at various intervals in advance of grouting. Wells CW-150 and BW-12 had existing perforations throughout most of their length. It was unnecessary to perforate these wells, except in the uppermost portion of the casing just before grouting. Wells BW-2 and BW-27 were perforated where necessary immediately prior to grouting. Tables 1 through 5 in the Draft Informational Field Report summarize the cementing operations at the five wells that were abandoned.

Well BW-1 was perforated on the first day of cementing operations. On that day, the cementing and drilling crews were set up at CW-150, when it was discovered that the packer would not fit the casing at CW-150. It was therefore necessary to delay the first abandonment for 3 days while Halliburton Services fabricated a new packer. To avoid

standby or additional mobilization charges during this period, the drilling crew was directed to perforate various intervals in BW-1.

At that early stage of the project, the abandonment approach was still being refined. The perforation of casing in advance of cementing was not regarded as a serious deviation from procedure, especially since two of the wells were already perforated throughout most of their length. The possibility of casing damage seemed remote, since perforation is a routine procedure and casing consisted of ½-inch-thick steel. The perforation of BW-1 was not communicated to Department staff, because at the time it appeared routine and insignificant.

Experience gained during the abandonment project will be applied toward future abandonment efforts at McClellan AFB. In the future, casing will only be perforated immediately prior to cementing. In addition, close communication will be maintained with the Department of Toxic Substances Control (the Department). All revisions and departures from written procedures will be cleared before taking action. The Draft Informational Field Report will be revised to more fully describe the perforation procedures followed during abandonment and to explain why BW-1 was perforated prior to cementing.

Comment: Field Notes--Field notes included in the Report lack systematic recording of page number, date, and site. Consequently, these deficiencies made reading the daily notes for each well difficult and confusing. It was difficult to ascertain which well was being described on any given page without searching through the whole body of notes.

Response: The page number was located at the top of each page. Notes were kept in chronological order, with the date placed at the beginning of each day's notes. The well at which work was taking place was described in the notes themselves, which may have made it difficult to locate references to a particular well quickly. The date and well location will therefore be added to each page of the field notes. In the future, notes will be organized as recommended in the Department comment below.

Comment: Recommendations for Future Decommissioning--Future well decommissioning should follow the guidelines detailed in the Procedures document. Well casing perforating for decommissioning should be done in stages as recommended by TSSB staff (Rich McJunkin) in the December 19, 1990, meeting with McClellan AFB staff and CH2M HILL personnel and described in McClellan AFB documents.

Field notes should be organized so that each page is numbered and dated. The well number or location should be written on each page. A fresh page should be used if the note-taker moves between wells. The field notes should include a daily sketch of decommissioning progress by depicting the well with grout intervals, knifing intervals, and other pertinent information.

Response: A Well Closure Methods and Procedures Report will be prepared for agency approval prior to the next phase of well decommissioning at McClellan AFB. Departures from approved procedures in this report will be undertaken only after receipt of advance approval from agencies. During the first phase of decommissioning, each well was abandoned in stages. In the future, wells will continue to be abandoned in stages, and perforations will be made immediately prior to grouting a given stage. Field notes will be kept as recommended here. These note-taking procedures will be described in the Phase II Well Closure Methods and Procedures Report.

Comment: Summary--Deviation from perforating and grouting methods described in the Procedures document and recommended by TSSB staff in the December 1990 meeting, likely caused a packer to become stuck and allowed filter pack invasion of Base Well 1. Filter pack invasion resulted in delaying decommissioning while filter pack material was removed by air lifting and the stuck packer removed. It also may have caused grout-take to increase during decommissioning.

The initial phase of well decommissioning at McClellan AFB was highly successful, and resulted in the development of an innovative approach to well abandonment that is unique and has broad applications to well decommissioning in locations where the groundwater may be contaminated in certain zones along the well casing. Each well was abandoned in stages, and only BW-1 was perforated in advance of grouting. It is uncertain whether that early perforation resulted in the filter pack invasion, or whether other factors such as defects in the casing led to the difficulties encountered on BW-1. However, in the future, wells will be grouted immediately after perforating a given stage. It is not unusual for problems to occur in field operations such as this, given the novelty of the approach, the age of the wells, the high pressures generated downhole, and the necessity to work remotely at depth without being able to see what is happening. During future decommissioning activities, McClellan AFB will collaborate with TSSB staff to devise the best strategies for dealing with technical problems as they arise.